Delta Salmon Project Work Team
Delta Juvenile Salmon Monitoring Program Review

Prepared by:
Pat Brandes, Katie Perry, Erin Chappell, Jeff McLain, Sheila Greene, Rick Sitts,
Dennis McEwan and Mike Chotkowski

July 5, 2000

Table of Contents

Abbreviations/shortened Word Forms Used in this Report

Bay	Suisun, San Pablo and San Francisco bays
CALFED Ops	CALFED Operations Group
CESA	California Endangered Species Act
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWT	coded wire tag
DAT	Data Assessment Team
DCC	Delta Cross Channel
Delta	Sacramento-San Joaquin Delta
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
FL	fork length
IEP	Interagency Ecological Program for the Sacramento-San Joaquin Estuary
NMFS	National Marine Fisheries Service
PWT	Project Work Team
Reclamation	United States Bureau of Reclamation
Salmon Protection Plan	Sacramento River Spring-Run Salmon Protection Plan
Slough	Montezuma Slough
Suisun Marsh SCS	Suisun Marsh Salinity Control Structure
SWP	State Water Project
USFWS	United States Fish and Wildlife Service
YOY	young-of-the-year

Executive Summary

A review of the Interagency Ecological Program for the Sacramento-San Joaquin Estuary (IEP)'s juvenile salmon monitoring program was undertaken to determine if the monitoring program was meeting its objectives and whether it should be modified to better meet present or future needs. Although part of the IEP program for many years, the juvenile salmon mark and recapture experiments are no longer funded by IEP and are not included in this review. The Central Valley Salmonid Project Work Team directed the review to be completed prior to funding this program for 2001.

This review describes the past, current and future goals of the program. We have assessed whether or not the monitoring program meets the goal of documenting the relative abundance and distribution of juvenile salmon in the lower Sacramento and San Joaquin rivers, Delta and Bay. Within the main goal, there are three objectives of the salmon monitoring program: 1) document the long-term abundance and distribution of primarily fall run juvenile salmon in the Delta, 2) comprehensively monitor throughout the year to document the relative abundance of all races of juvenile salmon, and 3) intensively monitor during the fall months for use in managing water project operations on a real-time basis. The data have been summarized and analyzed to determine whether the current levels of effort are appropriate or should be modified. Summaries of pilot activities are also included in the relevant sections to provide a better understanding of how the program has evolved. The data were also evaluated in terms of meeting the objectives of two other programs: steelhead and resident fishes.

The first objective of the program is to document long-term trends in abundance and distribution of juvenile salmon and how abundance may change with river flow. It appears that the present sampling program is adequately indexing the abundance of juvenile salmon (primarily fall run) residing in or migrating through the Delta in the beach seining between January and April, and mid-water trawls at Sacramento and Chipps Island between April and June. Relationships between abundance (density) and flow have been established and could be maintained with about half the present sampling. Sampling could be reduced from once a week to twice monthly for beach seine sites in the North Delta between January and March and from 3 to 7 days per week at Sacramento and Chipps Island to two days per week (possibly one day-per-week at Sacramento).

The sampling program also appears sufficient to meet the second objective: comprehensively monitor to document the relative abundance of all the various races of juvenile salmon in the Delta. Increasing beach seining in the Delta and Lower Sacramento River between October 1 and March 31 to twice a week was recommended. Suspending beach seining in the Bay between July and October, when juvenile salmon are not present was also recommended. A reduction in frequency of sampling at Sacramento and Chipps Island to two days a week (rather than three) during May and June also appears justified. Sampling at Mossdale should be employed year-round, three days a week, until it is firmly established that juvenile salmon do not enter the Delta during the summer or fall months.

The third objective of the program is to monitor the abundance of juvenile salmon between October 1 and January 31 for use in decisions regarding operations of the Delta Cross Channel (DCC) gates and water export levels for listed salmon species. The additional beach seine and Kodiak trawl sampling does appear to help insure the detection of the early part of the juvenile salmon emigration into the Delta and thus has been useful in making water management operation decisions. However, between mid- December and January 31 sampling could be reduced, by dropping the Sherwood Harbor, Sand Cove and Discovery Park beach seine sites and by sampling only three days per week with the Kodiak trawl at Sacramento. It is recommended that both Knights Landing rotary screw trapping and Sacramento Kodiak trawl continue because they each provide important information on the timing and relative of abundance of all races of juvenile salmon in the lower River and Delta, respectively.

The salmon monitoring program sampling also provides information relative to the movement of steelhead into the Delta (at Sacramento and Mossdale and in the beach seining) and past Chipps Island. Although conclusions regarding natural steelhead distribution, movement, and usage of delta habitats are limited from these data because natural fish and hatchery fish were not differentiated, this should not be a problem in future analyses because mass-marking of hatchery steelhead began in 1997 and will continue indefinitely. In addition, since 1999 the monitoring crews have implemented the life-stage assessment protocol developed by the IEP Steelhead Project Work Team (dated December 1998). Information from future steelhead recoveries in the salmon monitoring program will be enhanced from these recent changes and improve our knowledge of the migration patterns of steelhead through the Delta. Year-round sampling is beneficial to detect when the peaks of the various life-stages of steelhead are present at the various locations covered by the sampling program. Kodiak trawling is useful since it collects both young-of-the-year and yearlings and should be conducted between December and May. The current program has Kodiak trawling through March 31.

An evaluation was also conducted to determine the value of the monitoring program as a tool for addressing monitoring and research questions about non-salmonid delta-resident fishes. The review consisted of a brief description of the data-sets, a summary of anadromous and delta-resident fish species that are well-sampled by the beach seine program and those that are not, a statement of reasons why the data that have been provided by the program are valuable, and some recommendations for increasing the value of the program to management of delta-resident fishes. The review, relative to resident fish objectives, concluded that the beach seine program should retain its year-round sampling and geographical scope. These features, in combination with its long history make it a valuable resource for research and especially status and trends monitoring of resident fishes.

In general, the monitoring program appears to be meeting its objectives as well as the objectives relative to steelhead and resident fishes monitoring. Recommendations from steelhead and resident fishes biologists include incorporating steelhead and resident fishes monitoring objectives in the salmon monitoring program and including non-salmon biologists on the project work team or consulting other Project Work Teams regarding potential changes to the program. Minor modifications to the program have been identified and at times recommendations are contradictory or difficult to implement. For instance, a reduction in the months sampled in the Bay was recommended relative to the salmon objectives, but is counter to the recommendation for resident fishes to continue sampling in all months. Kodiak trawling is recommended in April and May for steelhead, although implementation of this suggestion would cause thousands more fall-run salmon to be caught in the midst of the relatively few steelhead. Discussions are needed with the Steelhead and Resident Fishes Project Work Teams to resolve any difficulties in meeting other objectives and in further defining any needed changes to the program.

To meet the salmon and other species objectives in the future it is imperative that the springtime and expanded monitoring continue because it provides a baseline to determine changes in these fisheries communities due to any future recovery or restoration action(s). The recommended changes to the program would not limit, and potentially improve our ability to make these comparisons in the future. Other changes to this program may be necessary, or separate programs may need to be initiated, to completely meet the needs of all species including steelhead and resident fishes that are not well sampled by this program. To further address the informational needs relative to juvenile salmon a review similar to this recommended for the mark and recapture component of the program in the Delta.

Introduction

The Interagency Ecological Program for the Sacramento-San Joaquin Estuary (IEP) presently funds a monitoring program to sample juvenile salmon throughout the lower rivers, Delta and Bay. This program presently costs approximately 1.1 million dollars of the 14 million-dollar IEP program. The purpose of this review is to determine whether the monitoring program is meeting its objectives, should be cut-back to provide more dollars for other programs within the IEP, should be augmented to meet future needs or left unchanged. The Central Valley Salmonid Project Work Team directed the review to be completed prior to funding this program for 2001.

This review describes the background and current and potential future goals of the program. The program's main goal is to document the relative abundance and distribution of juvenile salmon in the lower Sacramento and San Joaquin rivers, Delta and Bay. There are three main objectives of the salmon monitoring program: 1) document the long-term abundance and distribution of primarily fall run juvenile salmon in the Delta, 2) comprehensively monitor throughout the year to document the relative abundance of all races of juvenile salmon, and 3) intensively monitor during the fall months for spring-run chinook salmon for use in managing water project operations on a real-time basis. The data have been summarized and analyzed to determine if the current levels of effort are appropriate or should be modified. Survival studies on various life stages of hatchery reared chinook salmon have been conducted to evaluate the survival of juvenile salmon residing in and migrating through the Delta. Although these studies were part of the IEP program for many years, they are no longer funded by IEP and are not included in this review. Summaries of pilot activities are also included in this review in order to provide a better understanding of how the program has evolved. They are described in the relevant section by objective and include the reason(s) they were suspended or continued. The data were also evaluated in terms of meeting the objectives of two other programs: steelhead and resident fishes monitoring. Each section on the program's objectives contains a summary and recommendations. In addition, we have included a summary and recommendations for the whole program to identify any modifications proposed for the program in the future.

Background

The IEP's precursor was the Four Agency Cooperative Study which became formally established in July of 1970 and included participants from California Department of Fish and Game (DFG), California Department of Water Resources (DWR), U.S. Fish and Wildlife Service (USFWS) and U.S. Bureau of Reclamation (Reclamation). Fishery evaluations by USFWS and DFG were conducted in the late 1940's and demonstrated the need to screen Reclamation's Central Valley Project (CVP) water diversion intake near Tracy. In the 1950's studies and limited fieldwork led to a conclusion that insufficient facts were available to determine how DWR's State Water Project (SWP) should be constructed and operated to avoid adverse fish and wildlife impacts. Between 1961 and 1965 a series of studies on fish, wildlife and their food supplies were conducted in the Delta and Bay. Based on those studies, the issue of how water was being transported across the Delta and the proposed point of diversion in the south Delta were identified as fishery concerns with the through-Delta conveyance plan that tentatively had been selected by DWR prior to approval of the SWP. These concerns led to the recommendation of the Peripheral canal. Studies were initiated in 1966 to determine how the Peripheral Canal should be operated. Study elements were selected to address the highest priority concerns (i.e. striped bass, chinook salmon) which appeared to be the most vulnerable. DFG saw the reduction of Delta outflow as the key issue. Early surveys had suggested that small pre-smolt salmon used the Delta as a nursery and were potentially at risk from Delta water project impacts. Additional pilot studies focusing on salmon began in the early 1970's with the more formal and consistent work beginning in the late 1970's and early 1980's.

The salmon studies began with two primary objectives: 1) monitor young salmon abundance and determine the importance of the Estuary as salmon nursery habitat, and 2) determine how reduced river flows below the proposed Peripheral Canal intake (at Hood on the Sacramento river) would affect the survival of young salmon migrating through the estuary or using it as a nursery. After the Peripheral Canal concept was defeated by referendum vote by the people of California in 1982, a third study objective was added to evaluate the impact of through-Delta water conveyance on young salmon survival.

Springtime beach seine studies during the spring were initiated in the Delta starting in 1974. Sampling at a consistent set of stations in the lower Sacramento River and in the Central and North Delta between January and April was initiated in 1981 to index the abundance of juvenile salmon using the Delta as a nursery area. Mid-water trawling was conducted between April and June starting in 1978 to index the number of smolts migrating past Chipps Island. A similar mid-water trawling program at Sacramento was initiated in 1988 to index the number of smolts immigrating into the Delta. Kodiak trawling at Mossdale by DFG, Region 4, has also been conducted during the spring months since1987 (Figure 1). These studies focused efforts on juvenile fall-run chinook salmon, which are the run of highest abundance.

Survival studies on various life stages of hatchery-reared chinook salmon were also conducted to evaluate the survival of juvenile salmon residing in and migrating through the Delta. One study compared the survival of fall-run, fry-sized (< 70 millimeters) salmon using the Estuary as a nursery relative to those rearing in the upper Sacramento River. It was desired to determine how survival in each of these regions was affected by river flow rates. After the program was modified to evaluate the impacts of through-Delta water conveyance, the survival of fry released at different locations within the Delta also was compared.

Other survival studies using fall-run smolts (75-90 millimeters) in the Delta were conducted between 1969-1971 and since 1978. Smolts were released near Sacramento and downstream (Rio Vista and Port Chicago) as a means to estimate survival to determine the relationship between river flow and smolt survival. Releases were also made within the Delta to evaluate the differential vulnerability to water project operations based on release location. The relationship between river flow and survival was further explored by indexing survival while opening and closing the DCC gates. Survival has also been compared for smolts released on the main-stem

Sacramento River versus those released in the interior Delta (Georgiana Slough, North and South forks of the Mokelumne Rivers).

Studies have also been conducted since 1993 using late-fall yearlings released in the winter months to similarly evaluate the differential mortality between the interior Delta and the main-stem Sacramento River.

Although part of the IEP program for many years, the mark and recapture experiments are no longer funded by IEP and are not included in this review. We recommend that a separate review of these experiments be done in the future. The results of many of these experiments will soon be available in a report by Brandes and McLain (in press).

A major change in the direction for the salmon monitoring occurred as a result of National Marine Fisheries Service (NMFS) issuing biological opinions (dated February 14, 1992, and February 12, 1993) to the U.S. Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR). The biological opinions concluded that the proposed operation of the Central Valley Project (CVP) was likely to jeopardize the continued existence of winter-run chinook salmon. Incidental take statements were included which identified specific reasonable and prudent measures and associated terms and conditions that when implemented would minimize the impacts and avoid jeopardy of operating the CVP. The following text related to the monitoring of juvenile salmon in the Delta is taken from these biological opinions.

> "Continue and expand monitoring of winter-run chinook salmon to establish their presence and the period of time they occur in the lower Sacramento River and Sacramento-San Joaquin Delta."
>
> "….. The Bureau (Reclamation) must ensure that continuous real-time monitoring is conducted between October 1 and January 31 of each year commencing in 1993."
>
> "Continue and expand monitoring of winter-run chinook salmon in the lower Sacramento River and Sacramento-San Joaquin Delta to establish their presence, residence time, and serve as a basis for the real-time management of the Delta Cross Channel (DCC) gate operations."

In addition to the monitoring noted above, NMFS required Reclamation to conduct additional monitoring throughout the lower Sacramento River and Delta between September 1 and May 31 of each year commencing in 1993. A variety of gear and sampling locations were identified.

Reclamation and DWR were to provide assistance through funding or other means for the development and implementation of the identified monitoring and research programs.

An analysis of the1993-94 monitoring effort in the lower Sacramento River and Delta revealed that the sampling program did not effectively sample juvenile winter-run salmon. It was also determined unlikely that real-time operation of the DCC gates for the protection of winter run was possible. In addition, the current monitoring program was unable to quantitatively evaluate abundance of winter-run juveniles entering the Delta between October and January and, therefore the importance of Delta rearing could not be evaluated. The recommendations based on this analysis were to:

1) provide intensive sampling upstream of the DCC gates for entry of chinook salmon into the Delta;
2) sample with a variety of gear to ensure that juvenile chinook salmon of different sizes and vulnerabilities were effectively sampled;
3) sample on a daily basis, including day versus night, and at different tidal cycles; and
4) focus sampling effort at exit points from the Delta.

In response to these recommendations, the 1994-1995 monitoring program was revised to provide more intensive sampling at key locations, such as Sacramento, and used various gears to increase the ability to detect low numbers of winter-run juveniles. In addition, during fall storm events the monitoring was to be conducted 7 days per week.

On May 17, 1995, NMFS issued an amended biological opinion based on the revised State Water Resources Control Board Bay-Delta Standards and the Principles for Agreement on Bay-Delta Standards Between the State of California and the Federal Government (dated December 15, 1994). The biological opinion included three conservation recommendations to evaluate the losses of winter-run chinook salmon relative to the monitoring program:

1) intensive sampling in the vicinity of Sacramento to determine time of arrival, abundance and distribution of winter-run juveniles in the Delta to assist real-time operations and management decisions and
2) determine the level of take occurring to support real-time operations and management decisions using the data from the monitoring program
3) using data from the monitoring program and from coded wire tag (CWT) releases, determine the level of impact to winter run associated with Delta water exports to measure the effectiveness of the new standards and in-season operational decisions.

In June 1997, the California Fish and Game Commission (Commission) designated spring-run chinook salmon as a candidate species under the California Endangered Species Act (CESA). The Sacramento River Spring Run Salmon Protection Plan (Salmon Protection Plan) (October 1997) and its subsequent amendments (November 6, 1998) included recommendations for increased sampling effort in the Delta to assist the CALFED Operations Group (CALFED Ops) and its processes (e.g. Data Assessment Team - DAT) in making operational changes including closing the DCC gates.

In February of 1999, spring-run chinook salmon were listed as threatened under the CESA. In November 1999, Central Valley spring-run chinook salmon also was listed as threatened under the Federal Endangered Species Act. The previous year (May 1998), Central Valley steelhead also were federally listed as threatened. From December 1999 through March 2000, the 1998 Salmon Protection Plan was in effect and required additional sampling at Sacramento between October and December 1999 based on DAT recommendations.

Current and Future Goals of the Program

Current Goals and Objectives

The salmon monitoring program incorporated some additional objectives based on the needs identified in the biological opinions, the Salmon Protection Plan, and communication with the DAT. The current goal of the present Delta Juvenile Salmon Monitoring Program is to document the relative abundance and distribution of juvenile salmon in the lower Sacramento and San Joaquin rivers, Delta and Bay. The monitoring program presently uses three sampling gears, beach seining and mid-water and Kodiak trawling, to provide comprehensive information on the different life stages and sizes of juvenile salmon entering, residing in, and migrating from the lower Sacramento and San Joaquin rivers and Delta. As mentioned earlier there are three specific objectives within this general goal:

1) Document the long-term abundance and distribution of primarily fall run juvenile salmon in the Delta,
2) Comprehensively monitor throughout the year to document the presence of all races of juvenile salmon, and
3) Intensively monitor during the fall months for use in managing water project operations (DCC gates and water export levels) on a real-time basis.

Sampling has been conducted to evaluate the long-term trends of abundance and distribution of primarily juvenile fall-run salmon throughout the lower Sacramento River, Delta and Bay. Beach seining is conducted to index the number of fry using the lower rivers, Delta and Bay as rearing habitat. Mid-water trawling at Sacramento and Chipps Island has been conducted between April and June to index the number of juveniles entering and leaving the Delta, respectively. Indices of abundance have then been correlated to river flow to determine relationships.

Additional sampling has been conducted in recent years to better understand how all the salmon races and life-stages, use the lower rivers and Delta. Several beach seining sites have been added to document the timing and relative abundance of juvenile salmon in the South Delta and lower San Joaquin River. In addition, trawling has also been conducted at Mossdale, Sacramento and Chipps Island between October and March and at Sacramento and Chipps Island during the summer months (July through September). This additional sampling is designed to provide a more comprehensive, year-round assessment of the distribution and abundance of all races of juvenile salmon at these locations.

Intensified sampling near Sacramento with a Kodiak trawl and beach seine has also been conducted during the fall months to provide the needed information for real time operations of the DCC gates and export levels for the protection of spring-run and winter-run.

The program conducted in 1999-2000 is shown in Table 1. The objective of each program element is included in the table. Sampling is conducted between August and July of each year and is called a field season. The costs are also broken down by the three main objectives of the program in Table 2.

During 1999-2000 the DAT requested on short-notice additional beach seining and Sacramento River Kodiak trawl sampling during January 2000. This additional sampling cost an additional $9,800 and was obtained by redirecting funds from other sampling contained within the program.

One additional objective of the monitoring program is to assist other IEP programs by collecting information on non-salmon species caught in the sampling, collecting fish or other types of samples, contributing experienced crew and conducting data entry. Juvenile salmon and other species are kept for approximately ten other IEP research or monitoring programs. This assistance adds to the cost of the program, but has not been specifically identified.

The Delta Juvenile Salmon Monitoring Program, as well as the program objectives, has evolved over the past 20-plus years. Many pilot efforts have been conducted during this period; some of them suspended based on the results of the work, while others were integrated into the program. Pilot studies initiated between 1990 and 1998 are included. Further details on the methods and results of these pilot studies are included in the following annual reports: USFWS, 1990, USFWS, 1993, USFWS, 1994, USFWS, 1997, USFWS, 1998, USFWS, 2000.

Future Goals and Objectives

The CALFED Bay-Delta Program and the Central Valley Project Improvement Act (CVPIA) activities will implement changes in the Delta to improve fisheries production and/or protection, especially for listed salmonid species and races. Key biological questions require answers to be developed in the short-term to determine the priority and order in which the CALFED actions should be initiated to increase production and assist in recovery of listed species. It is also critical that these long-term monitoring programs continue, because they provide a baseline from which potential benefits of any future recovery or restoration actions can be determined. One question this review will address is whether the monitoring program needs to be changed to better address these short-term and long-term needs.

The Monitoring Program

Objective 1: Long-term abundance and distribution monitoring

The first stated objective of the program is to determine long-term trends in abundance and distribution of juvenile salmon. Long-term abundance and distribution trends are measured using beach seining at a set of regularly sampled sites between January and April and mid-water trawling at Sacramento and Chipps Island between April and June. In addition, we have analyzed the relationship between abundance and river flow and how reduction in sampling effort affects this relationship. Pilot efforts also have been conducted to determine relative abundance at certain locations within the Delta, but were not continued as it was determined resources would be better spent to fund a year-round sampling program at the established sites.

1) Beach Seine Sampling

Beach seining to document long-term abundance and distribution trends is conducted at 30 sites in the lower Sacramento River and Delta, seven of which are located between Colusa and Elkhorn (10 miles north of Sacramento) and twenty-three are in the Delta (Figure 1). The historical sites are divided into two areas of the Delta: North and Central. Ten of the original sixteen Bay stations sampled (includes Suisun, San Pablo and San Francisco Bays) between 1981 and 1986 were re-sampled starting in 1997. This sampling occurred once a week for all lower river and Delta stations and twice a month for the Bay stations (in 1981-1986 sampling was once a month) between January and April.

Indices of abundance have been generated using mean density (catch per cubic meter) for each area. The vast majority of juvenile salmon using the lower Sacramento River, Delta and Bay for rearing between January and April are fall run fry, with potentially some main-stem spring run. Abundance is generally highest in the lower Sacramento River and North Delta followed by the Central Delta (USFWS, 2000), and least abundant in the Bay (USFWS, 1987). The distribution of juvenile salmon has also been documented each year and in wet years salmon are generally more widespread and present in the Bay.

The average indices of abundance between January and March in the North Delta and Bay have been correlated with average Sacramento River flow at Freeport in February. Both relationships are significant at the $p<0.01$ level and indicate that as Sacramento River flow increases abundance (catch per cubic meter) increases. This positive relationship between Sacramento River flow and abundance indicates that flow may be important in stimulating downstream movement of juvenile chinook salmon. The sampling effort should be at a level that ensures continued monitoring of this relationship. This is one tool that can be used to assess the effects of future changes in flow or other habitat modifications.

The effect of reducing the frequency of beach seining in the North Delta and Bay on these established relationships was evaluated in this analysis. The results of these evaluations are presented below.

a) North Delta

Density of juveniles has only been measured since 1985 in the North Delta seining, because the area seined was not recorded between 1978 and 1984. The area seined for each seine haul is calculated by multiplying half the depth (*.5) by the width and length of the haul. The effort is divided into the catch producing a density measurement (catch per cubic meters).

The average catch per cubic meter for each three-month period (year) in the North Delta was calculated using two different summarization techniques. The first technique involved calculation of the mean of weekly means of each week to estimate the mean for the three-month period. This method gives equal weight to each weekly period. The second technique involves summing all catches during the three-month period and dividing by the total number of samples. This method does not correct for any possible variation in sampling effort over time. Mean Sacramento River flow during February at Freeport was calculated using daily values obtained from DWR (DAYFLOW).

Regressions were calculated to determine whether reduced effort would decrease the significance of the relationship between juvenile salmon catch per cubic meter sampled in the North Delta and Sacramento River flow. Full sampling effort and two hypothetical effort levels - half-effort level and quarter-effort level - were used in this evaluation. Full-effort data sets contained all data taken historically, which in most cases was weekly sampling at each North Delta site. Months were broken into four approximately equal periods. Portions one and three were used to represent half effort. In addition, portions two and four were also evaluated to achieve an additional estimate for half effort. Quarter-effort indices were calculated by using only the first portion of each month. Linear regressions were fit using the data from all four scenarios. Squared multiple R, probability, slope, and overall data integrity was compared between graphs. An analysis of covariance was done to determine if slopes differed significantly.

Figure 2 is a graph of the regression relationship of catch per cubic meter of chinook salmon between January and March in the North Delta beach seine (using the first summarization technique) versus mean February flow on the Sacramento River at Freeport. This relationship was developed using full effort (usually four times per month). The relationship is significant ($R^2 = 0.798$, $p = 0.000007$)(Table 3) and contains one minor outlier that can be resolved by a simple log transformation.

Figures 3 and 4 represent half effort while Figure 5 represents quarter effort. All models are significant at the 0.01 level, with only half effort using the first and third monthly portions containing a minor outlier (Figure 3).
Results using the second summarization technique were similar to the first summarization technique (Table 4) with slightly higher p values. All effort levels but the once monthly were significant at the .01 level.

An analysis of covariance was done using the historical effort methods to determine if there was a significant difference in the slope of the four types of efforts. Results indicate the slopes represent the same population ($R^2 = 0.694$, $p = 0.549708$).

The tightest, most significant relationship between flow and catch per cubic meter was observed using the full data set. This result was consistent using both methods of summarization. Approximately 78-80% of the increase in density is caused by an increase in flow when the full effort model is used. This model is significant beyond 0.00005. Cutting the effort to twice per month lowered the R^2 values, however, all models were significant beyond 0.05. Cutting effort to once per month reduced the R^2 to .542 and the probability to 0.001741 and 0.011360, respectively.

In summary, cutting the seining effort to twice monthly between January and March in the North Delta or half the historical effort would appear to have a minimal effect on the relationship between flow and catch of chinook salmon. Probabilities would decrease slightly but would likely still be within the bounds of a statistically significant relationship.

b) Bay

The density of juvenile salmon abundance, as measured with the beach seine catches at routine Bay sampling sites, was calculated using the first technique as described above for the North Delta seining sites. The full-effort analysis used historical estimates based on once per month monitoring between January and March from 1981 to 1986 and more recent sampling done twice per month between January and March during 1997, 1998, and 1999. To determine whether reduced effort would significantly jeopardize the robustness of the statistical analysis, full effort was compared to sampling at the same frequency but during February only.

The results of the full-effort analysis of density of juvenile chinook salmon abundance between January and March in the Bay surveys versus Sacramento River flow at Freeport is presented in Figure 6. Though the regression has an outlier, the R^2-value is 0.826 and the probability 0.0007. Figure 7 uses the same model except only February catches were used. The R^2 was 0.552 and the probability was 0.021891.

The scatter is considerably greater and the probability significantly declined when effort was reduced to only February. It appears that beach seining in the Bay needs to be continued twice per month between January 1 and March 31 in the Bay Seine to adequately document the presence of fry in the Bay relative to Sacramento River flow at Freeport.

2) Mid-water Trawl Sampling at Sacramento

Mid-water trawl sampling has been conducted between April and June in the Sacramento River near Sacramento since 1988. (In 1990, sampling was conducted further downstream near the town of Hood (Figure 1). Indices of abundance (mean catch per cubic meter) for juvenile salmon caught during this period of time were primarily fall run smolts that reared upstream and were in the process of migrating downstream to the ocean. Hatchery fish released upstream and subsequently captured during their migration through the Delta would have been included in the mean abundance indices generated each year for the three months. Average indices of abundance were not generated for 1992, when sampling was not conducted during the month of April. Indices of abundance (average catch per cubic meter) have been statistically significantly correlated to Sacramento River flow at Freeport. Smolt density of abundance varies inversely with river flow. This relationship appears to be consistent with the relationship between flow and fry density in the Delta, as potentially more of the fall-run juvenile salmon production enters the Delta as fry in wet years, with fewer entering the Delta as smolts.

Regressions were calculated using full historical sampling effort and two other hypothetical effort levels - half-effort level and quarter-effort level - to test whether a reduction in effort would decrease the significance of the relationship between river flow and juvenile salmon abundance indices. Catch per cubic meter was calculated by dividing the catch per tow by the net mouth area (m^2) and multiplying by the linear distance (m) traveled through the water (m) (Brandes and McLain, in press). Daily, weekly and monthly mean catch values were calculated to provide indices of abundance for April, May and June. Mean flow between April and June 30 at Freeport was calculated by averaging daily flow values for the three month period (DWR's DAYFLOW).

Historical data were gathered between three and seven days per week during the April to June period. Comparisons were made on three effort levels: three to seven days per week (full effort), two days per week (half effort), and one day per week (quarter effort). For the half-effort analysis, the first and last day of each weekly period was used. The first day of each weekly period was selected for the quarter-effort analysis. Regression results were compared for significance and slopes as done in the beach seine analyses.

The only regression model significant beyond the standard 0.01 probability observed was the full effort ($p = 0.0076$, Figure 8). The half-effort had a lower R^2 and probability ($R^2 = 0.4676$, $p = 0.0203$) (Figure 9). The quarter-effort produced a probability of 0.0404 and an R^2-value of 0.3890 (Figure 10). Analysis of covariance indicates that there is no difference in slopes ($p = 0.8490$, $R^2 = 0.4572$).

This analysis shows that reducing effort to two days per week and one day per week reduces the significance and the R^2 – value for this relationship. The quarter-effort remains significant at the 0.01 probability level ($p = 0.0063$) if the log of the dependent variable is used in the relationship.

A cut in effort to two days per week in the future to continue documenting the trend of density and flow at Sacramento would not appear to meaningfully weaken this relationship.

3) Mid-water Trawl Sampling at Chipps Island

Mid-water trawl sampling has been conducted at Chipps Island between April and June since 1978 to develop an index of the abundance of primarily fall-run smolts migrating to the ocean. This index provides a way of measuring primarily fall-run smolt production prior to entering the ocean environment. This index would include smolts released from Central Valley hatcheries. Historically all the hatcheries made releases upstream of Chipps Island, but since about the mid-1980's only Coleman National Fish Hatchery and Merced River Fish Facility make all of their releases upstream of Chipps Island. Indices of abundance have been generated for each month and for the three-month period. The monthly indices indicate that less fish are migrating past Chipps Island in June, than historically, which may reflect a change in hatchery practices where smolts are released earlier in the three-month period to avoid high losses due to high temperatures (USFWS, 2000). Absolute abundance estimates for the three-month period have also been generated using a variety of techniques (USFWS, 1994 and USFWS, 2000) and have found that absolute estimates of abundance have ranged between 5 and 53 million smolts. A statistically significant relationship has been found between mean Sacramento River flow at Rio Vista and catch per cubic meter of juvenile salmon at Chipps Island between April and June. As flow increases the density of smolts increases.

To determine if the effort at Chipps Island could be reduced, an analysis similar to that conducted for the beach seine and Sacramento mid-water trawl sampling was conducted to test whether a reduction in effort would decrease the significance of the relationship. Again, regressions were calculated using full effort conducted historically and two hypothetical effort levels: one day per week and two days per week.

Catch per cubic meter was calculated similarly to that using the mid-water trawl at Sacramento. Mean flow also is calculated similarly although it is at Rio Vista instead of Freeport. The first and last day sampled of each weekly period was used to calculate a two-day effort. The first day sampled of each weekly period was selected for the one day per week analysis.

As Figure 11 indicates, 52% of the change in density of smolts at Chipps Island between April and June (reported as catch per cubic meter) is associated with an increase in flow on the Sacramento River at Rio Vista. The probability associated with this is 0.00015 (Table 5). Figures 12 and 13 are two day- and one day per week effort regression models, respectively.

All three effort levels were significant and had acceptable results for the model, however, the one day per week model R^2 was only 0.365 and p value was 0.003; significantly lower than the two day or the full effort. Although, correlation analysis was not done as it appears the slopes are not different between the three types of efforts.

The results of this comparison show that a reduction in effort to one or two days per week would not meaningfully weaken this relationship.

4) Pilot sampling to index abundance

Various pilot studies were conducted in 1987, 1990, 1992 and 1993 to calculate the index of abundance of juvenile salmon at various locations, in different season and diurnal and tidal cycles. In 1990, limited sampling was conducted in Sutter Slough and the DCC as well as just upstream of these channels on the main-stem Sacramento River to determine if fish were being diverted into these channels in proportion to flow. A mid-water trawl net, similar in size to that presently being used at Sacramento was used. The sampling was also conducted in the Sacramento River at this location and near Courtland to determine if juvenile salmon were equally distributed across the channel in the main-stem Sacramento River at these two locations upstream from these two major diversion points. It was thought that downstream juvenile salmon migrants might be more vulnerable to being diverted into Sutter Slough or the DCC if their distribution across the channel was higher on the side of the channel where the channels originated. For limited periods sampling was also conducted on both tidal cycles (ebb and flood) at some locations.

No significant differences were found between the east, middle and west sides of the channel at any of the three sites, although in four of the six measurements we found a higher catch rate on the east side of the main channel above the DCC. Juvenile salmon were not being diverted into the two diversion channels in relation to flow, as the densities in the diversion channels were consistently lower than the densities in the main channel. Based on limited (n=10) day and night sampling at Courtland there did appear to be a higher catch rate at night although it was not significant at the 95% confidence level. No significant differences were found in catch per tow between an ebb and flood tide at any of these sites. However, the relationship between the densities in the DCC and in the main-stem upstream of the DCC changed during ebb and flood tides. There were more fish in the main-stem Sacramento River than in the DCC during ebb tides there were no significant differences during flood tides.

A pilot study conducted in 1990 used a mid-water trawl in February and March to sample winter- run smolts at Hood (Hood, 1990) to compare the results to a similar survey conducted in 1973 (Schaffter, 1980). The 1990 index of abundance was about 60% lower than that obtained in 1973. This study concluded that the lack of consistent data from previous years and the inability to distinguish the different runs limited the ability to make accurate assessments of the numbers of fish present. A year-round, survey to establish a baseline for year to year comparisons was suggested.

Mid-water trawling was also conducted in Montezuma Slough (Slough) for 10 days, in April 1992 and May 1993. In 1992, sampling was conducted downstream of the Suisun Marsh Salinity Control Structure (SCS) and in 1993 sampling was conducted both upstream (above) and downstream (below) of the Suisun Marsh SCS. The purpose of the 1993 study was to develop an estimate of the percent of salmon being diverted into the Slough by comparing these trawl data with data collected simultaneously at Chipps Island. In addition, the significance of the losses was determined by comparing the trawls above and below the Suisun Marsh SCS. The mean percent diverted was estimated to be 2.5 %, which is higher than estimated in 1987 (not described here) and 1992. Significant differences ($p< 0.05$) were detected in catches above and below the Suisun Marsh SCS indicating that once diverted into the Slough the SCS can be a source of significant salmon losses.

5) Summary and Recommendations

It appears that the present sampling program adequately documents the long-term abundance and distribution trends of juvenile chinook salmon. The program also indexes the abundance of juvenile salmon (primarily fall run) residing in or migrating through the Delta in the beach seining between January and April, and mid-water trawls at Sacramento and Chipps Island between April and June. Relationships between abundance (density) and flow have been established and could be maintained with sampling between January and March reduced from once a week to twice monthly for beach seine sites in the North Delta, and maintaining sampling at twice a month for the beach seine sites in the Bay. It also appears that reducing sampling from three to seven days per week at Sacramento and Chipps Island to two days per week (possibly one day per week at Sacramento) could also be done to reduce costs without meaningfully harming the relationships between abundance and flow. The pilot studies detected significantly lower densities of juvenile salmon in the DCC relative to those in the Sacramento River during ebb tides. Significant differences in catch were also detected above and below the Suisun Marsh SCS. These pilot efforts were suspended because resources were allocated to establishing year-round sampling at historical locations to index the abundance of all races of juvenile salmon entering and leaving the Delta.

Objective 2: Sampling to index the relative abundance of all races of juvenile salmon

The second objective of the program was to expand the sampling to more comprehensively sample in time and space to document the presence/absence and relative abundance of all the various races of juvenile salmon in the Delta. Beach seining and trawling at Sacramento and Chipps Island was extended to almost year-round and a variety of other methods were explored to determine the absolute abundance of various races and life-stages residing in, entering or leaving the Delta. Since both fry and smolts enter the Delta at Sacramento and the gear is size and habitat selective, an attempt was made to determine if catch per cubic meter from various gears could be combined to estimate the absolute abundance of the various races of juvenile salmon entering the Delta.

1) Beach Seine

The beach seine sampling was expanded in 1994 to additional areas (lower San Joaquin River), to more sites within sparsely sampled areas (South Delta) and expanded to other months of the year to more comprehensively document the presence/absence and relative abundance of all races of salmon rearing in the lower Rivers, Delta and Bay (Figure 1). Sampling is conducted once a week all year in the lower Sacramento River and North Delta stations. Sampling is also conducted year round in the Central and South Delta but is reduced to only once every other week between July and December. Seining in the lower San Joaquin River is conducted weekly between January and June, as low water prevents consistent sampling during the summer and fall. Sampling in the bays is conducted twice monthly year-round.

Catch per month and catch per cubic meter for each of the races of juvenile chinook salmon (identified using Fisher's (1992) size criteria) between 1992-1993 and 1998-1999 field seasons for the lower Sacramento River and Delta is shown in Tables 6-8. The fall/spring-run categories based on the size criteria have been combined since the main-stem spring-run and fall-run are known to be hybridizing with main-stem fall-run. Spring-run are now only found in the tributaries of the Sacramento River and are thought to migrate through the Delta primarily as yearlings between 70 and 150 millimeters fork length between October 1 and December 31. The catches of these juvenile salmon in the beach seining are reported in Table 9. These fish overlap in size with late-fall and winter-run defined using the size criteria and should not be viewed as additive to the other catches. Spring-run fry emigrate at about the same time and size as fall-run and are visually indistinguishable from each other in the spring months.

Larger sized late-fall run in the beach seine on the lower Sacramento River are present between August and February. Monthly catches are low, ranging from 0 to 29. Maximum catch per cubic meter value (x 100) was 0.825, considerably lower than winter-or fall/spring run maximums. Peak migration occurred in December during five of seven years analyzed. In 1993-1994 the peak occurred in October, and in 1998-1999 it was in November. Fry were captured during the spring (April through June) in five of the seven years. Juvenile late-fall chinook salmon were detected on the lower Sacramento River during all months except March and July (Table 6).

Monthly catches of larger late-fall (present between October and February) in the Delta were even lower than the Lower Sacramento River ranging from 0 to 18. The highest catch per cubic meter (x 100) was during December of 1999 at 0.0049. The seasonal peak catches typically occurred in January but ranged between November (1992-1993 field season) and February (1995-1996 field season). Fry catches between April and July also were evident in the Delta. No late-fall were observed during August, September, and March between 1993 and 1999 (Table 6).

Monthly winter-run catch and catch per cubic meter in the lower Sacramento River are higher than observed with late-fall fish ranging from a low of 0.0006 (during March of 1999) to a high of 3.515 (during December of 1997). The highest monthly catch in the lower Sacramento River occurred in December of 1996, when 119 winter-run were captured. Seasonal peak catches in the lower Sacramento River ranged between November and February with the most common month for peak catch per cubic meter in January. Peak seasonal catches in the Delta typically occurred in December and January, but occurred once in February (Table 7).

As observed with late-fall salmon, winter-run numbers are lower in the Delta than in the lower Sacramento River. Catch per cubic meter (x 100) values in the Delta ranged from 0.0002 (March 1995) to 0.017 (December 1999). A high catch of 73 winter run during December of 1995 was observed (Table 7).

Relatively high numbers of fall/spring-run were captured in the lower Sacramento River. Catches ranged from 0 to 3,854 (during February of 1996) (Table 8). Peak seasonal density typically occurred in February, but ranged from January to March. The highest density observed was 3.955 in March of 1999.

Catches of fall/spring-run in the Delta beach seine were also relatively high and peaked in February and March. The temporal distribution is slightly later in the Delta (February and March) compared to the lower Sacramento River (February).

Monthly catch for the size range of chinook salmon caught between 70 and 150 mm in seining in the lower Sacramento River and Delta is shown in Table 9. This size range is used to isolate larger sized fish, presumably spring run yearlings. Catches are variable but peak captures consistently occur in December, with the exception of the November 1993 catch in the Delta.

Beach seining was also conducted starting in 1994 in the lower San Joaquin River between January and June. Fall run fry were observed in the seining between January and June with peaks primarily in February, with peaks in some years in March and April (Table 10).

Beach seine sampling was expanded to be conducted year-round in the Bay during 1997, 1998, and 1999 to determine the year-round use of the Bay by salmon. No salmon were captured between late-May and early-December for all years during expanded sampling.

Based on these data, it appears that the frequency of beach seine sampling alone may not be adequately measuring the relative abundance of all the various races and life-stages of salmon using the lower rivers, Delta and Bay. Catches of tributary spring run in the lower Sacramento River and Delta beach seine between October and December are variable and can be low. Juvenile winter-run salmon are also migrating into the lower Sacramento River and Delta during this time (October 1 - March 31). Catches of winter-run vary greatly between years and months, totaling as few as 28 fish during the entire year (1993-1994). Late-fall are equally as scarce during this time even though it is their primary migration period. Because winter-run and larger juvenile chinook from the spring and late-fall races are relatively rare in the seining during dry years, a doubling of effort (to twice a week) is recommended between October and March 31 to enable peak detection. Beach seining is probably less effective at sampling larger sized juveniles due to net avoidance and this may limit our ability to detect peak numbers. Spring and early summer sampling (April, May, and June) catches mostly fall/spring-run sized juvenile salmon and, also important, late-fall fry in low abundance. It is recommended that sampling continue at its present level for the detection of these late-fall-run fry. (This recommendation would supercede that based on the long-term abundance and distribution objective (reduce beach seine sampling to once every two weeks) discussed in the previous section.) The sampling during the summer (July, August, and September) captures late-fall juveniles, winter-run fry, and fall/spring-run yearlings all in low abundance. It is also recommended that sampling continue at the present level (once a week or twice a month, depending on location) to assure presence and absence information during these months. Beach seining in the lower San Joaquin River appears to be adequately indexing the numbers of fall run fry using the lower San Joaquin River between

January and June. Sampling in the Bay could be reduced to the period between November through June when juvenile chinook salmon are present.

It is recommended that beach seine sampling increase in the Delta and Lower Sacramento River between October 1 and March 31 to better document peak abundance of juvenile salmon moving into and through the Delta during this period. We recommend that beach seining in the Bay be suspended between July and October since juvenile salmon are too scarce during this time period for the effort needed to adequately sample them. All other sampling is recommended to continue at its present level.

2) Pilot efforts to evaluate other gears and methodologies

Several pilot efforts were initiated in 1992 at different sites along the Sacramento River to determine whether additional gear should be used to measure the number of juvenile salmon passing by upstream sites and entering the Delta and to determine how fast fry move into the Delta. These pilot studies included rotary screw trapping near Princeton and Colusa, fyke net sampling at Colusa, Knights Landing and Sacramento, and repetitive beach seining and tow net sampling at Sacramento.

Rotary screw trapping was conducted near Princeton (3-5 days and nights per week from August 31 to December 31, 1992) and near Colusa (five days and four nights per week from September 9, 1993 to June 15, 1994) to detect juvenile salmon movement down the Sacramento River. Although rotary screw trapping was determined to be a suitable sampling gear the sampling was discontinued to focus on detection of the various races of juvenile salmon entering the Delta. In 1995, DFG initiated a pilot rotary screw trapping program at Knights Landing.

Fyke net sampling was conducted between September 28 and November 3, 1992 at river mile 140 (near Colusa) and between November 5 to 9, 1992 at Knights Landing to monitor the movement of fry passing these upriver sites. A fyke net was also fished at Knights Landing between October 27, 1993 and March 31, 1994. No winter or late-fall run were captured in the Knights Landing fyke net during the 1994 season. Based on these results fyke net sampling was suspended at these locations based on the premise that the beach seine could be used to document the presence and absence of juvenile late-fall and winter run and was the preferred alternative.

Two fyke nets were deployed one on each side of the Sacramento River near Sherwood Harbor Marina in Sacramento (within our mid-water trawling reach and fished two to three times per week both during the day and at night between January 21 and June 10, 1992. Catches (as number per minute) were less with the fykes than for the mid-water trawl at Sacramento. The mean size caught all months was less in the fyke nets than that caught in the mid-water trawl.

Fyke sampling was also conducted in sequential years: between November 9, 1992, and June 2, 1993, between October 4, 1993, to May 26, 1994, and between September 26, 1994, and January 5, 1995. The sampling in 1994 and 1995 was increased to four days and nights per week. In

1994, comparisons were also made between mean size of salmon caught in the fyke nets versus the mid-water trawl at Sacramento and the Delta beach seine sites. Fyke nets usually caught smaller fish than either the trawl or seine.

Between January and May of 1992 and between October 1993 and May 1994, no winter or late-fall run were captured in the fyke nets. Between November 1992 and January 1993, 27 winter run and 7 late fall were recovered. No salmon were recovered in the traps between September 1994 and January 1995.

In the fall of 1994, a study was initiated to quantify catch per unit effort in the fyke nets set near Sherwood Harbor on the Sacramento River. The primary problem encountered was the change in flow due to tidal influences prevented the fyke nets from continuously fishing. At times low water would cause the fyke nets to be out of the water on certain tidal cycles. The second problem encountered was that it was not possible to estimate a catch per cubic meter since the volume of flow through the net would change throughout the tidal cycle. Further fyke netting was suspended because catches could not be standardized within the gear and, therefore, could not be added to those caught with the Kodiak/mid-water trawl fished in the main part of the channel to estimate the total number of the various life-stages of salmon entering the Delta.

The results of the repetitive beach seining indicated that fry move into the Delta near Sacramento during March and April on average of 0.0023 fish per minute, and repopulate the area about three-fold in 24 hours. The tow net sampling indicated that the tow net consistently caught less fish in the smaller size range (less than 73 millimeters) than the mid-water trawl (76 versus 262). The concern that the mid-water trawl would not effectively catch small fry in the middle of the channel (at least under those flow conditions in the spring of 1992) appeared to be unfounded.

Various methods have been employed to estimate absolute abundance of the various life-stages in the Delta. An attempt was made in 1992 to estimate the absolute abundance of fry in the Delta using tagged fry recaptured in the seining. A total of 183 coded wire tagged fish was recovered from the 102,862 coded wire tagged fry released. During the course of the season 4,083 unmarked fish were collected in the seining. Based on the ratio of recaptures to those released, 2,295,002 unmarked fry were estimated to have been in the Delta and lower Sacramento River between December 1991 and the end of May 1992. This likely was a minimum estimate as many of the recaptures (120 of 183) were recovered at one of the release locations seven days after release and most likely biased the recovery rate high and, consequently, the absolute abundance estimate low. Omitting the 120 and using 63 as the recapture value yields an estimate of 6,666,437 unmarked fry.

Recoveries from these release groups were also made from one to nine days after release and continued for up to 30 days. Five to ten fry from each release were recovered in the mid-water trawl at Sacramento and four in the tow net. This indicated that fry from these groups moved into the Delta over a long period of time and that at least some portion was moving downstream via the middle of the channel. Flows during this period were high and may have swept the fry into the middle of the channel, whereas during periods of lesser flow the fry would perhaps move downstream nearer to the shore.

One of the release groups of marked fry was released at Miller Park on March 16 with the majority of recoveries occurring on March 16-17 in the fykes at Sacramento. During March 16-17 fykes on both sides of the Sacramento River were in operation for 47% of the time during these two days. Given that 37 of these fish were recovered during the two-day period (24,350 released), it equates to an efficiency rate of 0.0016, and an efficiency rate of 0.0032 when corrected for sampling time. If we expand the unmarked catch (n = 2656) based on this efficiency rate, corrected for the fraction of the time sampled over the course of the season (0.27), then 6,148,148 fry passed our fykes during the course of the season. This estimate is similar to the one based on the beach seine recoveries.

3) Kodiak and Mid-water trawling at Sacramento

Starting in December of 1994, Kodiak trawling was initiated to index the number of low abundant, larger juveniles (late-fall, winter-run and spring-run yearlings) entering the Delta. Since then, the Kodiak trawl has been generally used between October 1 and March 31 of each year. The mid-water trawl is used primarily between April and June (see previous section). Catch per month as well as catch per cubic meter of all the races of juvenile salmon between 1993 and 1999 field seasons for the Kodiak and mid-water trawl at Sacramento are shown in tables 11-14. Effort at Sacramento alternated between the mid-water and Kodiak trawl depending on the time of year, weather, debris in the river, and mechanical problems. Peak catches and densities should be viewed with this in mind since each gear was not fished for the entire season.

Juvenile late-fall salmon were captured every month at Sacramento with the exception of March and May (Table 11). Larger juveniles were captured between August and February, with the seasonal peak typically occurring in November and December, but as early as October and as late as January. Fry were in low abundance between April and July. The highest number (30) and density (0.332) were observed in the Sacramento mid-water trawl in December of 1995.

Winter-run were present in the trawls at Sacramento between October and April, with seasonal peaks typically occurring in February and March, but as early as November in 1999 (Table 12).

Fall/spring-run-sized chinook were captured between August and July in the Sacramento River mid-water and Kodiak trawl (Table 13). Catches ranged from a low of 1 fish to a high of 6,588 in April of 1994. Peak densities typically occurred in April, but ranged from January to May. Larger young-of-the-year (YOY) were captured in August and September, yearlings in November, fry in December, January, February, and March, and smolts in April, May, June, and July.

Monthly mid-water and Kodiak trawl catches of chinook salmon between 70 and 150 mm at Sacramento between October and December is displayed in Table 14. Seasonal peak catch typically occurred in December, but peaks also occurred in October and November.

In summary, mid-summer to early fall sampling (July, August, and September) yielded sparse numbers of late-fall juveniles and larger fall-run young-of-the-year. Abundance is too low for peak determination but presence and absence is documented. A continuation of sampling at three days per week is recommended. Sampling between October and March 31 is critical to detect winter run and late-fall run migration trends. It is essential to retain this effort (3 days per week) to continue documenting the presence and absence of these juvenile salmon. Sampling during April, May, and June normally is done three days per week. Catches during this time are comprised mostly of fall/spring-run smolts, winter-run (April only), and some late-fall fry. Because the beach seining is better equipped to capture late-fall fry, and the fall/spring-run are in such high abundance, a cut back in effort to two days a week (rather than three) during May and June at Sacramento would be justified. Because winter-run are still present in April, it is recommended to continue at three days per week during April.

a) Kodiak trawl versus mid-water trawl at Sacramento

The relative efficiency of the two different gears was compared to determine whether the additional cost of the Kodiak trawl relative to a mid-water trawl is justified. The Kodiak trawl was selected to increase capture of the larger chinook salmon that are of lower abundance (winter-run, late-fall-run and yearling spring-run salmon) near Sacramento. The larger mouth opening of the Kodiak trawl net increases the chance of capture of these races of juvenile salmon.

Numerous studies investigating the relative efficiency of these two nets have been unsuccessful due to insufficient catches. A week-long comparison study on the Sacramento River was conducted in April of 1996 following a Coleman National Fish Hatchery production release. The objective of the study was to determine if the Kodiak trawl caught more of the larger salmon. The catch per unit effort was also compared to determine if the Kodiak trawl was overall more efficient in capturing juvenile salmon.

The results of the study indicated that the mean length of juvenile salmon captured by the Kodiak trawl was 2 mm greater than those captured in the mid-water trawl. It should be noted that the juvenile salmon in the Sacramento River during the time of this study were mostly composed of Coleman National Fish Hatchery fall run which were of similar size. The study also found that the two gears covered comparable linear distance during a tow, however, the effective fishing mouth opening of the Kodiak trawl was larger and is built differently than the mid-water trawl net. As a result, the Kodiak trawl captured more salmon per tow than the mid-water trawl, but density values were not found to be significantly different. The larger catches in the Kodiak trawl appear to be a function of the greater volume sampled due to the larger net. The conclusion from the study was that the Kodiak trawl should continue to be utilized to maximize catch efficiency of the larger chinook salmon which are less abundant in the Sacramento River.

It is recommended that this comparison be repeated during December or January when larger fish are in the system to determine if there is any size selectivity between the two gears for the larger fish present in the winter months.

b) One boat versus two-boat Kodiak trawl

In 1998, a separate comparison was made between the Kodiak trawl towed with one boat versus that of the Kodiak trawl towed with the standard two boats. There was no significant difference in the catches from the two different boat set-ups. Although, it is less costly to run the Kodiak trawl with one boat, there were some safety concerns relative to controlling the single boat with using such large doors in the river thus the sampling using one boat was not pursued further for implementation.

It is recommended that mid-water and Kodiak trawl sampling continue three days per week between July and April, but reduce sampling frequency to two days-per-week in May and June. It is also recommended that comparison sampling be conducted with the mid-water and Kodiak trawl in December or January to determine the differential size selectivity of the two gears. It is not recommended that a Kodiak trawl be used with only one boat because of safety concerns.

4) Pilot efforts to index winter-run salmon in the Central Delta

Additional pilot efforts, pushnetting, mid-water trawling and rotary screw trapping, were conducted to index the number of juvenile winter-run salmon at various locations in the Central Delta.

Pushnetting was conducted at various locations both in the lower Sacramento River and in the central and southern Delta between September 30, 1992 and April 2, 1993. Initial pushnetting started between river miles 131 and 137. After a late-October storm 117 juvenile salmon were caught. The pushnetting was then moved to the DCC, Georgiana Slough and southern Delta where a total of five wild and six fin-clipped salmon were caught. Pushnetting did not appear to be a very effective gear for sampling juvenile salmon in the Delta due to its small mouth opening and slow speed through the water.

Mid-water trawling was conducted in the central Delta two to three times per week between January 7 and April 1, 1993. Sampling was conducted in the Mokelumne River near its junction with the San Joaquin River and in Georgiana Slough, near its junction (within a half mile) with the Mokelumne River. It was also conducted on the Mokelumne River three times weekly from January 7 to February 16, 1994. Although, the presence of juvenile late-fall and winter-run salmon were documented in the Central Delta, catches were low and it was not possible to assess the relative abundance of winter run entering the Central Delta.

Rotary screw trapping was conducted in the DCC between June 21 and June 30, 1993, between September 28, 1993, and January 6, 1994, and between October 13, 1994, and January 4, 1995. The rotary screw trap sampling in the DCC was suspended in 1995 after observing that only a few salmon were caught and that the trap only effectively fished during flood tides when the height of the Sacramento River caused higher velocities through the DCC. Currents were not sufficient enough to turn the cone on the trap during ebb or slack periods.

These pilot efforts were suspended because the gears were inefficient for catching winter run and were not useful in estimating the relative abundance of juvenile winter run in the central Delta.

5) Kodiak trawling at Mossdale

Sampling was conducted at Mossdale between September and December of 1996, March and June of 1997, and November and June 1998-1999. The sampling between September and March has been conducted as part of this sampling program whereas that between April and June has been conducted by others (DFG, Region 4 and IEP Real time monitoring). This sampling has been conducted to monitor juvenile salmon entering the Delta whose origins were the San Joaquin River tributaries. Juvenile salmon were observed between January and June, but not observed between September and December (Table 15). Sampling has not been conducted between July and August. It is recommended that sampling be extended to year-round until it is established that juvenile salmon originating from the San Joaquin basin either do not enter the Delta in these non-sampled or rarely sampled months (July through December), or are too scarce to be detected by the sampling gear used.

6) Mid-water trawling at Chipps Island

Sampling at Chipps Island was extended to the period between October 1 and June 30, to improve the index of juvenile salmon of all the races leaving the Delta. In some years, sampling was also conducted between July and September. Catch and catch per cubic meter for all the various races of juvenile salmon emigrating from the Delta are shown in tables 16, 17, 18 and 19.

The trawl at Chipps Island captured late-fall sized juvenile salmon every month of the year except March, April, and June (Table 16). Larger sized late-fall were captured during the fall and winter (August through February) while fry were captured in the late spring and summer (May and July). Densities were generally low with the highest density in November 1999 at 0.378. Monthly raw catch at Chipps Island varied from 0 to 74 (December 1997).

Catch and catch per cubic meter of winter-run chinook caught at Chipps Island are shown in Table 17. Catches of winter run at Chipps Island occurred between December and May and peaked in March during all years (Table 17). Catch per cubic meter (x 10,000) ranged from 0.001 (May 1994) to 0.595 during March of 1996.

Catch of fall/spring run at Chipps Island varied greatly ranging from one fish per month to more than 20,000 during May of 1998 (Table 18). Catch per cubic meter (x 10,000) values were higher than any other race, with peak density occurring five out of six years analyzed in May. Larger young-of-the-year and yearling-sized fall/spring run are captured between August and

November. Fry were captured during December, January, February and March and smolts were captured between April and June.

Yearling spring-run between 70 and 150 millimeters were captured at Chipps Island between October and December, with seasonal peaks occurring in December (Table 19).

Because the beach seining is better equipped to capture the late-fall fry, and the fall/spring run are in such high abundance, a reduction in effort to two days (rather than three) a week during May and June at Chipps Island would be justified. The remaining months of the year, sampling is recommended at present levels (three days-per-week).

7) Summary and Recommendations

Current sampling effort appears sufficient to comprehensively document the presence/absence and relative abundance of all the various races of juvenile salmon in the Delta. The recommended changes to the sampling program include increasing beach seine sampling in the Delta and Lower Sacramento River between October 1 and March 31 to twice a week and suspend beach seining in the Bay between July and October. A reduction in frequency of sampling at Sacramento and Chipps Island to two days a week (rather than three) during May and June also appears justified. It is recommended that the Kodiak trawling continue to be employed between the months of October and March, but that a comparison be conducted between the mid-water and Kodiak trawl in December or January to verify that the Kodiak trawl is catching more of the larger juvenile salmon. Sampling at Mossdale should be employed year-round at three days a week, until it is established that juvenile salmon either do not enter the Delta during the summer or fall months, or are too scarce too effectively sample.

Objective 3: Monitoring for Operational Decisions

To meet the third objective of the program, monitoring the abundance of juvenile salmon for use in decisions regarding operations of the DCC gates and water export levels for listed salmon species, additional beach seine sampling and Kodiak trawling between October 1 and January 31 has been conducted.

Decisions must be made quickly to be effective in CVP and SWP operations. To accomplish this, the CALFED Ops established working groups to reach consensus at the lowest possible level while assuring that all CALFED Ops participants are informed. The working groups include the Data Assessment Team (DAT), which is composed of biologists from the CALFED Ops agencies and stakeholder groups and the No-Name Group which is comprised of a representative of each CALFED Ops member agency and interested parties. The CVP and SWP operations staff participates as consultants to the DAT on the operations of the two projects. The DAT compiles and interprets fishery-related data, disseminates the interpreted information to the CALFED Ops, and makes recommendations on actions. The DAT objectives regarding Delta salmon are to compile and interpret current natural and hatchery salmon data collected in the sampling.

The DAT has two types of Delta salmon data needs. The first need is to promptly receive data from ongoing sampling efforts, and the second need is to potentially request new sampling on short-notice. The DAT uses the data from the salmon monitoring program to determine whether spring or winter run juvenile salmon are entering the Delta, and to formulate recommendations on when to close the DCC gates or when and how much to curtail exports to protect these fish.

In addition, the Central Valley Project Improvement Act (CVPIA) Section 3406(b)(2)-implementation team also participates in the DAT. They use Delta salmon program data to decide on when and how much CVPIA Section (b)(2) water to use for the protection of anadromous fish.

The additional effort using the Kodiak trawl and beach seines in the Sacramento River near Sacramento during the fall months is per NMFS' 1992, 1993 and 1995 biological opinions for winter run and the November 6, 1998 Salmon Protection Plan. The Salmon Protection Plan calls for "Collection of yearling size chinook salmon (70-150 mm) in the sampling on the Sacramento River at Knights Landing or Sacramento or at beach seine sites in the Delta." The salmon monitoring data collected near Sacramento or in the Delta contribute to determining sensitive periods for spring run for use in determining appropriate operational responses such as closure of the DCC gates depending on water quality concerns. Other Salmon Protection Plan operational responses are considered (reduction in exports) based on observations in the sampling program of spring-run-sized juvenile salmon concurrent with the collection of tagged late-fall-run juvenile salmon at the SWP or CVP fish facilities. The tagged salmon are released in the Delta or Sacramento River. Finally, trends in the catch of marked or unmarked salmon in the monitoring program are used in conjunction with CVP and SWP salvage data to determine whether project impacts on yearling spring-run are likely to change in the immediate future.

The DAT has occasionally requested additional monitoring by the Delta Juvenile Salmon Monitoring Program. The additional sampling has been conducted by redirecting resources from other aspects of the program. Questions in this review include whether the program meets the needs of DAT and the Salmon Protection Plan and whether the increased sampling helped in detecting the movement of larger juvenile salmon into the Delta. Since the DAT procedures have not been reviewed there are neither data nor consensus on the extent to which the Delta Juvenile Salmon Monitoring Program meets DAT needs and this objective of the program. Occasionally incorrect data have been reported to the DAT. In order to prevent a recurrence of this event additional resources should be allocated to this aspect of the program.

Two analyses were conducted to determine whether the increased effort between October 1 and January 31 in the beach seining and Kodiak trawling has improved the detection of larger, juvenile salmon moving into the Delta for operational decisions. The first analysis was conducted to determine whether the increased frequency and addition of new beach seine sites in the North Delta produced new information over that obtained as part of the seining conducted to meet other objectives of the program. The second analysis evaluated whether the increased sampling with the Kodiak trawl at Sacramento provided additional information over that gained from the sampling conducted as part of the other objectives of the program.

1) Beach seine analyses

Historically beach seine stations along the Sacramento River, from Verona to Garcia Bend, were only sampled one day per week until 1995. The historical stations included Verona, Elkhorn Slough, Discovery Park, and Garcia Bend. Since 1995 the sampling effort was increased to three or more days a week at each station plus three additional stations were added: Sand Cove, Miller Park, and Sherwood Harbor. Chinook recoveries at both the historical and additional stations, between October and March, were compared to the estimated chinook recoveries at just the historical stations, from 1995 to 2000. The additional stations were also compared to the historical stations to determine if they provided any additional information on yearling spring run and winter run size chinook emigration and detection. Therefore, chinook whose lengths were above the minimum winter run length line (using Fisher, 1992, size criteria) were used.

In the 1994 field season sampling was conducted only at the historical stations one day per week and is included as an example of yearling spring run and winter run detection in a dry year (Figure 14). However, in field seasons 1994-1995, 1995-1996, 1996-1997, and 1999-2000 sampling was generally conducted three or more days a week, while in field seasons 1997-1998 and 1998-1999 sampling was generally conducted three days a week. In order to compare the historical sampling effort to the current sampling effort only the stations that were sampled three or more times per week were used. The number of chinook recovered per week was determined for three different sampling efforts. The first sampling effort is the total number of chinook recovered for both the historical and additional stations when sampling is conducted three or more days a week. The second sampling effort is the total number of chinook recovered for both the historical and additional stations assuming a sampling effort of only three days a week. If the sampling effort was greater than three days a week the total number of chinook recovered was adjusted by randomly removing one or more days of recoveries. For example, if the stations were sampled five days in a week then two day's worth of recoveries were randomly removed. The third sampling effort is the total number of chinook recovered at the historical stations only assuming a sampling effort of one day per week. The number of chinook recovered was determined by randomly removing all but one day's worth of recoveries for each week.

Sampling only one day per week at the historical stations was sufficient to detect the presence of yearling spring run and winter-run size chinook (Figures 15-20), when abundance was high, in each field season. There were seven weeks where yearling spring run and winter-run size chinook would have been missed by reducing the sampling effort. These incidences occurred in November 1994, February 1995, March 1996, January 1997, February 1997, November 1999, and January 2000 (Figures 15, 16,17, and 20). A similar pattern of recoveries occurred where seasonal peaks appear in the same week for both three or more days a week and one day per week sampling; the only exception was the1998-1999 field season (Figures 19). The seasonal peak in recoveries occurred between late November and early January (Figures 15-20).

The highest number of chinook were recovered at Elkhorn Slough between October and March in every year except 1996-1997 (Table 20). Sand Cove, Discovery Park, and Sherwood Harbor typically had the lowest number of chinook recoveries while Verona, Miller Park, and Garcia Bend had intermediate recoveries for this same time period (Table 20). The earliest seasonal recoveries occurred at Sherwood Harbor in 1994-1995, 1996-1997, and 1997-1998 and the earliest average recovery date occurred at Sherwood Harbor in all years except 1995-1996 (Table 20). Sand Cove and Discovery Park were also important stations for early detection of yearling spring run and winter run size chinook (Table 20). Miller Park had the latest recovery date in 1995-1996, 1996-1997, and 1997-1998 and generally had recoveries over a long time period compared to the other stations (Table 20).

Since the peak in yearling spring run and winter-run size chinook recoveries generally occurred between late November and early December, increasing sampling prior to this peak is important for the detection of chinook during this period when juvenile salmon abundance is low. Sampling three or more days a week at Elkhorn Slough, Sherwood Harbor, Sand Cove, and Discovery Park during this time period provided valuable information on the presence or absence of yearling spring run and winter-run size chinook and the timing of emigration. Sampling both the historical and additional stations a minimum of three days a week from October through mid-December would help insure detection of the early part of the emigration. The contribution from Sherwood Harbor, Sand Cove, and Discovery Park was minimal from mid-December until the end of January and provided less information than the other stations. Reducing sampling effort from mid- December through January 31 to a maximum of three days a week and removing the Sherwood Harbor, Sand Cove, and Discovery Park stations, would be sufficient for the detection of yearling spring run and winter run size chinook. It would also provide sufficient information on the emigration pattern of yearling spring run and winter-run size chinook.

2) Sacramento River Kodiak Trawl Evaluation

Increasing the sampling frequency of Kodiak trawl sampling at Sacramento from three days per week to five to seven days per week was analyzed to determine whether such an increase provided useful information for real time water project operations. The Delta Juvenile Salmon Monitoring Program increased Kodiak trawl sampling near Sacramento to more than three days a week in January 1995. Since then, the sampling conducted from October through January has ranged from one day a week early in the season to as much as seven days a week later in the season. Typically the station is sampled at least three days a week. Chinook recoveries using the Kodiak trawl were evaluated to determine if sampling more than three days a week has provided substantially more data. In order to determine the benefits of the increased sampling only the weeks that were sampled three or more days a week were used in the evaluation.

During the period October through January, real time water project operations near Sacramento are affected by yearling spring run and winter-run chinook emigration. Therefore, only chinook whose lengths were above the minimum winter run length line (using Fisher, 1992, size criteria) were used in the evaluation. The number of chinook recovered per week was determined for the two different sampling efforts. The first sampling effort was the total number of chinook recovered when sampling was conducted three or more days a week. The second sampling effort was the total number of chinook recovered assuming a sampling effort of only three days a week. If the sampling effort was greater than three days a week the total number of chinook recovered was adjusted by randomly removing one or more days of recoveries. For example if the station was sampled five days in a week then two day's worth of recoveries were randomly removed.

In field seasons 1995-1996, 1996-1997, and 1997-1998 the number of juvenile chinook recovered increased from five to eighteen fish per year, starting in mid- December (Figures 22-24, Table 21). In field seasons 1994-1995 and 1998-1999 there was no difference in the number of chinook recovered when the sampling effort was increased (Figures 21 and 25). Increased sampling had the largest impact in 1996-1997 when the total number of chinook recovered was increased by 23 percent (Table 21). When all years are combined the number of chinook recovered increased by 29 fish or by 10 percent (Table 21).

The peak in chinook recoveries generally occurred between late November and early December (Figures 21-25). Traditionally the sampling effort in October has been less than three days a week. However, sampling three days a week from October through November would be beneficial for detecting the onset of the peak emigration of yearling spring-run and winter-run chinook. Sampling three days a week from November through January would also be sufficient for the detection of yearling spring-run and winter-run chinook, as increased sampling during this period did not provide significantly more information.

In January 1995 the sampling program increased Kodiak trawl sampling near Sacramento to more than three days per week. Since then, the sampling conducted between October and January has ranged from one day per week early in the season to as much as seven days a week later in the season. Typically the station is sampled at least three days per week. Chinook recoveries using the Kodiak trawl near Sacramento were evaluated to determine if sampling more than three days per week has provided substantially more data. In order to determine the benefits of the increased sampling only the weeks that were sampled three or more times per week were used in the evaluation.

Only chinook whose lengths were above the minimum winter-run length line, based on the Frank Fisher model were used in the evaluation. The number of chinook recovered per week was determined for the two different sampling efforts. The first sampling effort was the total number of chinook recovered when sampling was conducted three or more days per week. The second sampling effort was the total number of chinook recovered assuming a sampling effort of only three days per week. If the sampling effort was greater than three days per week the total number of chinook recovered was adjusted by randomly removing one or more days of recoveries. For example if the station was sampled five days per week two day's worth of recoveries were randomly removed.

Sampling three days per week was sufficient to detect the presence of winter-run-sized chinook between October and January for all years 1994-1995 to 1998-1999 (Figures 21-25, Table 21). In 1994-1995 and 1998-1999 there was no difference in the number of chinook recovered when the sampling effort was increased (Figures 21 and 25). However, in 1995-1996, 1996-1997, and 1997-1998 the number of chinook recovered was slightly increased ranging from five to eighteen fish per year, with an increase in sampling effort (Figures 22-24, Table 21). Increased sampling had the largest impact in 1996-1997 when the total number of chinook recovered was increased by 23 percent (Table 21). When all years are combined the number of chinook recovered increased by 29 fish or by 10 percent (Table 21).

The seasonal peak in juvenile chinook salmon recoveries typically occurred between late November and early December (Figures 21-25). Therefore, the increased sampling effort from early November through mid- December appears to be beneficial to detecting the presence of winter run size chinook. However, by mid- December the number of chinook in the area has increased substantially and increasing the sampling would not provide significantly more information.

3) Comparison of sampling at Sacramento versus Knights Landing

The juvenile chinook salmon relative abundance catch information obtained at Sacramento by Kodiak and mid-water trawl was compared to that obtained by rotary screw trap at Knights Landing to determine whether this is a duplication of effort. The surveys were evaluated by comparing recoveries at both sites, from October through January, for field seasons 1995-1996, 1996-1997, 1997-1998 and 1998-1999. The chinook recoveries were also divided into two groups based on fork length. Group 1 contained chinook whose lengths were above the minimum winter run length line (using Fisher, 1992, size criteria). Group 2 contained chinook whose lengths were below the minimum winter run length line. The minimum winter run length line was chosen to separate yearling spring run and winter run size chinook from young-of-the-year chinook. Yearling spring run and winter run chinook were separated from young-of-the-year chinook to help evaluate differences in the numbers and emigration patterns of each group.

The Knights Landing sampling typically uses two traps, 24 hours per day, seven days a week while the Sacramento trawls typically sample for 200 minutes per day, three days a week for the time period between October and January. In order to compare the sites, the recoveries at both sites were expanded to catch per week to account for lower sampling effort in the Sacramento trawls and any deviations from the typical sampling effort. A sampling effort expansion value was determined for the rotary screw traps based on the maximum sampling time of 336 hours per week (2 traps * 24 hours * 7 days). The sampling effort expansion value for the Sacramento trawls was determined based on the maximum sampling time of 1400 minutes per week (200 minutes * 7 days).

The number of chinook recovered in the rotary screw traps between October and January was substantially higher than the number of chinook recovered in the Sacramento trawls, for all years, for both Group 1 and Group 2 (Table 22). For Group 1, the number of chinook recovered in the rotary screw traps each year ranged from 225 to 669 compared to 27 to 118 chinook recovered in the Sacramento trawls (Table 22). For Group 2, the number of chinook recovered in the rotary screw traps each year ranged from 7,023 to 12,761 compared to 339 to 5,678 chinook recovered in the Sacramento trawls (Table 22).

The timing of the recoveries, between October and January, for both groups were similar for both the rotary screw traps and the Sacramento trawls (Figures 26-41). The peaks in recoveries occurred the same week except for yearling spring run and winter-run recoveries in 1995-1996 and 1998-1999 where the peaks in recoveries occurred a week earlier in the Sacramento River trawl (Figures 26, 27, 40, and 41). The average recovery date for juvenile late-fall-run chinook salmon released in November, December, and January was two days earlier in the rotary screw traps on than the Sacramento trawls for releases made in 1997-1998 and 1998-1999. However, for both the November releases in 1997, and for one of the two November releases in 1998, juvenile late-fall-run chinook were recovered in the Sacramento trawls one week to one month earlier than in the rotary screw traps (Table 23). Juvenile winter-run chinook salmon were recovered in the rotary screw traps from two days to six weeks earlier than in the Sacramento trawls (Table 23).

Chinook recovered in the rotary screw traps typically had a broader length frequency distribution than the chinook recovered in the Sacramento trawls each month (Table 24, Appendix 1: Figures 1-48) and for all years combined (Figures 42 and 43) for both groups. However, the average fork length of Group 1 chinook recovered in the rotary screw traps was smaller than the average fork length of those recovered in the Sacramento trawls for each month (bold values in Table 24). The difference in the average monthly fork length ranged from zero to 50mm (Table 24). The minimum fork length was smaller and the maximum fork length was larger in the rotary screw traps compared to the Sacramento trawls for all months except November and December 1996, and October 1997 and 1998 (Table 24, Appendix 1: Figures 9 and 10). The average monthly fork length of Group 2 chinook was much closer between the two sites with a maximum difference of only 4mm (Table 24). Like Group 1, the minimum fork length was smaller and the maximum fork length was larger in the rotary screw traps than in the Sacramento trawls except for December 1995 and January 1999 (Table 24, Appendix 1: Figures 3, 4, 47, and 48).

The relationship between the weekly capture rates in the rotary screw traps and the Sacramento trawls between October to January varied between the years. For Group 1 the relationship between the two gear types was not very strong with an average R^2 value of 0.50 for all years combined (Figure 48), with the R^2 value ranging from 0.04 to 0.94 (Appendix 1: Figures 49, 51, 53, and 55). The relationship between the two gear types was stronger for Group 2 with an average R^2 value of 0.66 for all years combined (Figure 49), with the R^2 value ranging from 0.58 to 0.91 (Appendix 1: Figures 50, 52, 54, and 56).

DFG compared juvenile salmon catches in several gears at Knights Landing and in the Kodiak trawl at Sacramento for field season 1995-1996 (DFG, 1998). These comparisons included the continuous rotary screw traps at Knights Landing with 3 weeks of concurrent Kodiak trawling at Knights Landing, with concurrent fyke netting at Knights Landing, and with concurrent Kodiak trawling at Sacramento. DFG concluded the rotary screw traps captures a higher proportion of the smaller Chinook (<50mm) than the Kodiak trawl at either Knights Landing or Sacramento. Using a rank statistical test, they concluded the weekly catch trend, between December 17, 1995 and April 6, 1996, and lumping all sizes of juvenile chinook, was significantly different between the 2 locations. But when they divided the catch into four size subcategories (fall, spring, winter and late fall), they concluded the catch trends were similar. DFG's conclusion based on four size subcategories is similar to the conclusion from the analyses here based on two size subcategories. The catch trend between the two locations is not very different even considering Knights Landing sampling did not occur the week before the peak of the emigration of larger sized salmon emigration.

It is recommended that both Knights Landing rotary screw traps and Sacramento Kodiak trawl continue because they each provide important information. Knights Landing rotary screw traps provides more information on the number, size range, and emigration timing of both yearling-spring- and winter-run length chinook, and young-of-the-year chinook. The Knights Landing rotary screw traps recovered more fish per effort and was not effected by high flows as frequently as the Sacramento Kodiak trawl. The rotary screw traps is operated 7 days per week and 24 hours per day, providing diurnal information daily. The Sacramento Kodiak trawl provides information at a site closer to the DCC and is a better indicator of when yearling-spring- and winter-run size chinook are entering the Delta and susceptible to diversion at the DCC gates. In 1995 and 1996, juvenile late-fall-run chinook salmon were detected at the Sacramento Kodiak trawl before they were detected at Knights Landing. Since the Sacramento trawl is downstream of the confluences of the Feather and American rivers with the Sacramento River, the trawl provides information on timing and abundance of fall-run young-of-the-year.

4) Summary and Recommendations

The additional beach seine sampling from October through mid-December ensures detection of the early part of the emigration and thus has been useful in making water management operation decisions. However, between mid-December and January 31 sampling could be reduced by dropping the Sherwood Harbor, Sand Cove and Discovery Park sites. This reduction in sampling would be sufficient for the detection and emigration pattern of yearling spring run and winter-run size chinook. The increased Kodiak trawling at Sacramento between early November and mid-December appears to be beneficial to detecting the presence of winter-run-sized chinook. However, by mid-December the number of chinook in the area has increased substantially and increasing the sampling does not provide significantly more information. It is recommended that both Knights Landing rotary screw traps and Sacramento Kodiak trawl continue because they each provide important information on the timing and relative abundance of all races of juvenile salmon in the lower River and Delta, respectively.

Steelhead

1) Life History

Central Valley steelhead (winter steelhead) enter the rivers between July and May, with peak movement in late September through March. They spawn mainly from December through April, but can begin as early October and extend through June (McEwan, in prep). Central Valley steelhead juveniles remain in freshwater from one to two years (Hallock et al., 1961). Steelhead typically remain at sea for one to four years before returning to fresh water to spawn. Emigration timing for juveniles is dependent on flows, but generally ranges from December through early May and peaks February-March.

2) Monitoring Data

The monitoring data between 1976 and 1997 have been previously summarized in graphs and consist of : 1) catch-per-unit-effort by month for mid-water trawling at Chipps Island and Sacramento, and Kodiak trawling at Sacramento (Figures 46, and 47); (2) catch by area (5 areas) for beach seining (Figure 48); and (3) length frequency graphs for all years combined for Sacramento mid-water trawl and Kodiak trawl (Figure 49), Chipps Island mid-water trawl (Figure 50), and beach seine (Figure 51).

Based on the information contained in these graphs we summarized the more recent monitoring data obtained in the 1990s. Trawling data between 1995 and 1999 were summarized as daily catch of yearling-sized steelhead (100 to 300 mm fork length) in the Kodiak trawl at Sacramento (Figure 52), in the mid-water trawl at Sacramento (Figure 53), and at Chipps Island (Figure 54). Beach seine data from 1990 to 1999 were summarized in graphs of daily catch of young-of-the-year steelhead (Figures 55 a and b), daily catch of yearling steelhead (Figure 56), and daily catch of adult steelhead (Figure 57). Mass marking of hatchery-produced steelhead began with fish released in 1998; consequently, most of the data represent both hatchery- and naturally-produced fish combined.

a) Chipps Island Mid-Water Trawl

In the 1970's and 1980's trawling was conducted primarily in the spring (Figure 46, a and b). Steelhead data reflected this effort with catch occurring in April, May and June. Due to the limited seasonal sampling it is not possible to distinguish modes in the catch distributions. In 1993-1994 trawling effort was expanded to nine months of the year (October through June), and from 1995 through 1997 trawling was conducted year-round (Figure 46 c). Steelhead data again reflected this effort and it is possible to distinguish modes in catch distribution. In 1993-1994 steelhead were caught from January through June, with peak catches in February. In 1994-1995, 1995-1996, and 1996-1997, steelhead were caught between October and June, with peak catches in February and March. Steelhead captured in the Chipps Island trawl range in length from approximately 35 to 700 mm fork length (FL) (Figure 50). Length frequency graphs show a distinct mode between 160 and 300 mm FL, with a peak at 220 mm FL. These fish may represent yearling (100-300 mm FL) steelhead that are moving out of the Delta. A graph of yearling-sized fish caught at Chipps Island between 1995 and 1999 indicates that this may be the case (Fig. 54). This mode however may be mostly composed of hatchery yearlings, and emigration timing through the Delta may be heavily biased by release timing of hatchery fish. Unfortunately, there is no way to draw conclusions from these data regarding emigration timing of naturally-produced smolts through the Delta.

b) Sacramento Mid-Water Trawl

In 1988, 1989, and 1991, trawling was conducted only in the spring months (Figure 47 a). Steelhead were captured in April and May of each year. From 1992 to 1997 trawling effort increased and steelhead were observed generally between January and May, with greatest catches occurring in February or March. Length frequency graphs indicate that the range of lengths observed is approximately between 40 and 690 mm FL (Figure 49 a). Similar to the Chipps Island trawl data, there is a distinct length frequency mode between 160 and 300 mm FL. Yearling-sized steelhead caught between 1995 and 1999 are shown in Figure 53. Since 1995 the catch of yearling steelhead has decreased. In 1998 and 1999 no yearlings were caught in the months of January, February or March - yearlings were caught in April and May only.

c) Sacramento Kodiak Trawl

Kodiak trawling was conducted in 1994-1995 between the months of December and April (Figure 47 b). In 1995-1996 it was done between October and April, and in 1996-1997 it was done between October and March. Steelhead were observed from January through April in 1995 and 1996. A few steelhead were caught in November 1996 and more were caught in February and March 1997. Length frequency graphs indicate that the range of lengths observed is approximately between 35 and 720 mm FL (Figure 49 b). Once again, there is a distinct mode between 160 and 300 mm. There is also a secondary, smaller mode between 35 and 50 mm. Catch of the yearling-sized steelhead between 1995 and 1999 is shown in Figure 52. As in the mid-water trawling, it appears that catch has decreased in recent years. The length frequency data indicate that the Kodiak trawl may be more efficient at capturing young-of-the-year (YOY, FL < 100 mm) steelhead than the mid-water trawl. The significant capture of YOY steelhead is interesting and may indicate that YOY steelhead continue to utilize the delta for rearing, although this could be an artifact of the past hatchery practice of culling fry steelhead from the hatchery raceways and releasing them into the river.

d) Beach Seine

Beach seining has been conducted since 1976, although effort in different regions of the Delta and San Francisco Bay have varied over the years (described elsewhere in this report). Steelhead catch is greatest in the Upper (North) Delta, followed by the Mid (Central) Delta, and the Sacramento River upstream of the Delta (Figure 48). Length frequency graphs indicate that the range of lengths observed is between 25 mm and 425 mm FL (Figure 51). There is a distinct mode between 25 and 55 mm FL and perhaps a secondary mode between 55 and 100 mm FL. These are YOY steelhead. Catch of these two size groups of YOY fish for the lower Sacramento River, North Delta and Central Delta are shown in Figure 55 a and b. It is likely that these YOY represent hatchery releases in the Delta because these fish are not caught in the lower river. Since 1998 all hatchery-produced steelhead have been adipose fin-clipped; data in Figures 55 a and b, which depict un-clipped fish only, indicate virtually no catch in the last three years. The data in Figure 56 depict a protracted mode between 100 mm and 300 mm FL, which would represent yearling (100-300 mm FL) steelhead. These fish are present in all three areas, however there have been none caught since mid-1997 (Figure 56). Only three adults have been caught in the beach seine and these were caught in the November to December time period; two in the lower river and one in the North Delta (Figure 57).

3) Summary and Recommendations

Mid-water trawling at Chipps Island and Sacramento samples all life stages, but may be most effective at capturing yearling-sized steelhead. Kodiak trawling at Sacramento appears to capture both YOY and yearling steelhead (and fewer adult size fish than at Chipps Island and Sacramento), but is probably less effective at capturing YOY than yearling fish. Beach seining captures both YOY and yearling steelhead, but is most effective at sampling the smaller YOY steelhead.

Conclusions regarding natural steelhead distribution, movement, and usage of delta habitats that can be made from these data are limited because natural fish and hatchery fish were not differentiated. This should not be a problem in future analyses because mass-marking of hatchery steelhead began in 1997 and will continue indefinitely. However, because the hatcheries release their entire steelhead production usually over a short period in late winter/early spring, this can heavily influence when juvenile steelhead are detected in past monitoring activities.

We know very little about movement and habitat usage of natural steelhead through the Delta, consequently, we know relatively little about important potential impacts, such as Delta water operations, on steelhead survival. Since 1999 the monitoring crews have been collecting gross origin (hatchery or wild) information and have implemented the Steelhead Life-Stage Assessment Protocol developed by the IEP Steelhead Project Work Team (dated December 1998). Future analyses will benefit from collecting this information by improving our ability to determine origin, to detect life-history changes as steelhead migrate through or rear in the delta, and by documenting the presence of wild steelhead smolts as they exit the river systems and enter the delta.

Differences between chinook salmon and steelhead in life history, size at emigration, and anthropogenic effects requires that steelhead data be collected through a focused monitoring effort, and not collected incidentally in salmon monitoring activities (IEP Steelhead PWT 1999). A steelhead monitoring program could be modeled after the salmon monitoring program, and would overlap considerably with chinook salmon monitoring efforts so that a complete duplication of effort would not be necessary. However, a more focused effort on steelhead would require that some additional effort be maintained or expanded, particularly during those time periods where chinook salmon monitoring is currently not done or has been proposed to be reduced. Steelhead monitoring should include emigration timing, movement, and habitat usage (rearing and/or migration), coupled with life-history parameters such as size, growth, gross origin (hatchery or natural), and life-stage (IEP Steelhead PWT 1998).

The salmon monitoring program sampling is beneficial to informational needs of steelhead relative to the movement of steelhead into the Delta, at Sacramento and Mossdale and past Chipps Island. Year-round sampling is beneficial to detect when the peaks of the various life-stages are present at specific locations. Kodiak trawling is useful because it collects both YOY and yearlings and should be conducted between December and May; presently it only samples through March. Sampling at Mossdale is especially important because previously undetected steelhead populations are being found in San Joaquin River tributaries. Monitoring juveniles as they move into the Delta and past Chipps Island would be useful to determine timing and relative abundance of San Joaquin River system steelhead as they enter and leave the estuary. Beach seining also collects YOY steelhead and sampling throughout the year in the lower Sacramento River and Delta could be used to document the rearing of wild steelhead in the these downstream areas.

Resident species

1) Value of the Program to resident fishes

An evaluation was conducted to determine the value of the salmon monitoring program as a tool for addressing monitoring and research questions about non-salmonid delta-resident fishes. The review consisted of a brief description of the data-sets, a summary of anadromous and delta-resident fish species that are well-sampled by the beach seine program and those that are not, a statement of reasons why the data that have been provided by the program are valuable, and some recommendations for increasing the value of the program to management of delta-resident fishes. This aspect of the review deals almost exclusively with the beach seine program, but it is worth noting that the Chipps Island mid-water trawl survey is used to generate a splittail index by the USFWS regulatory staff (Stephanie Brady, personal communication.).

Between March 8, 1976 and March 29, 1999, the USFWS beach seine database includes records of 17,789 seine hauls from 125 different stations, yielding 687,589 fishes. Proportional abundance calculations reported in Table 25 (Appendix 2) were based upon data collected between January 1994 and March 29, 1999, a period in which 9,707 seine hauls at 74 different stations yielded 464,424 fishes. The seine data are dominated by inland silverside and chinook salmon, which account for about 59.5% of fishes caught. Threadfin shad, red shiner, Sacramento sucker, Sacramento pikeminnow, western mosquitofish, and striped bass are also relatively abundant: the eight most relatively abundant species account for a total of 90.9% of fishes taken. At present red shiner is seined in large numbers only in the San Joaquin River system, and is the only abundant species in the Delta seine assemblage that is not widely distributed. Thirty of 61 species were non-indigenous, accounting for about 59.3% of all fishes taken.

To provide a summary for which the beach seine program is useful, particularly in assessing status and trends, and who has been using the data recently, a table was compiled (Table 25, Appendix 2). The table reports all fish species that have been taken by the beach seine and Chipps Island mid-water trawl, whether those data sources are likely to be useful for status and trends monitoring, and whether, for each species, somebody has used these data sources for research or status and trends evaluations.

Almost all fish species occurring in the Delta are represented in the table. However, a few categories of fishes are not adequately sampled and it seems little, other than their presence at sampling stations, can be learned about them from this program. These include such benthic fishes as sculpins and gobies, benthopelagic nocturnal or crepuscular fishes (mainly catfishes), and fishes of any species that are too mobile to be readily captured in a minnow seine. Among species of management relevance, the last group particularly includes adult splittail. If and when a comprehensive monitoring program is constructed, other gears will have to be employed to sample these species and life stages.

Vegetation-associated fishes, a category that includes centrarchids, mosquitofish, rainwater killifish, threespine stickleback, some minnows, and tule perch, also are not well-sampled.

Nevertheless, for many of these the seine program would be useful for status and trends monitoring in conjunction with data from other sources, as part of a comprehensive monitoring program. Data from other sources are essential for fishes that occur in the beach seine only as YOY.

Fishes that seem to be sampled reasonably well at one or more life stages by the salmon monitoring program include northern anchovy, clupeids, some cyprinids, juvenile Sacramento sucker, atherinids, juvenile striped bass, and a short list of other mostly small fishes (see table 22). Among listed resident species, YOY splittail are fairly well sampled by this gear. Some of the well-sampled species are already subjects of management attention; adequate regional monitoring of those that are not could probably be accomplished by regular review of the beach seine and salvage data alone.

Furthermore, the seine program samples shallow shore habitat that harbors an assemblage of fishes (and life stages) different from what is found in deeper, easier to sample channel waters. Besides the adults of a variety of nearshore fishes, the seine takes young-of-the-year fishes of species that are not, as adults, specifically associated with delta shore habitats that can be seined. This group includes the listed delta smelt and Sacramento splittail, among others.

That the beach seine program might be useful for purposes other than salmon monitoring is no surprise. It spans a relatively long period (about 1976 – present), and during a large portion of that period management attention to delta-resident fish species was less than it is now. It was not until delta smelt were listed in the early 1990s that monitoring of delta-resident fish species became a high priority. Even now, the only geographically distributed IEP monitoring activity besides the beach seine program that samples delta-resident fishes not conveniently caught in trawls is the Resident Fishes Monitoring Study (Dave Kohlhorst, principal investigator), which is a nearshore electrofishing program conducted in odd-numbered years since 1995. (An earlier manifestation of the electrofishing program conducted during 1980 – 1983 used a different methodology and isn't really comparable.) Apart from differences in what is sampled – the electrofishing is done in waters from less than a meter to about 5 m depth over various substrata and vegetation types, while the seine is used on bare substratum in less than about 1.5 m depth – the methodologies have drastically different biases and provide complementary, not exchangeable, information.

The beach seine database is unique both because it involves routine sampling of fishes at geographically diverse locations in the delta and because it has persisted for 24 years. As a result, it is a primary resource to those interested in sorting out population time trends and (mainly seasonal) changes in distribution; it is also useful because it allows one to infer the timing of YOY recruitment to the seine gear, which can be informative to those investigating the relationships among recruitment and various hydrologic and other environmental variables.

The great value of the beach seine (and Chipps Island mid-water trawl) for resident fishes derives from its longevity. Having many consecutive years of data is not only valuable because it likely provides data with various degrees of contrast among values of environmental variables (e.g., multiple data from each of several water year categories), but also because it provides a basis for exploring interannual serial dependencies (such as stock-recruitment relationships, if they exist). Additional methodologies, like time series analysis (sensu Box and Jenkins) will become more practical when the series reaches about 30 uninterrupted years in length. These methodologies can be extremely useful for generating hypotheses about the ecology of fish species.

The beach seine monitoring program provides additional valuable information about the timing of recruitment of species (e.g. delta smelt and splittail) having juveniles that occur in or rear in shallow water that can be seined. This information may be critical in the long term for status and trends evaluations. In many species, environmental conditions modulate timing of spawning, with the result that date of recruitment is variable and there may be recruitment spikes separated by intervals. The potential resolution of this program at present can be as small as several days, because there are some stations on the Sacramento main-stem that are sampled almost daily during the winter and early spring. While the program's emphasis on fall-winter-spring sampling includes the period of maximum interest for resident fishes as a whole (winter-spring), it is unfortunate that sampling has historically been sparse or nonexistent during the summer. For species that recruit to the gear in spring, or are present year round, having the summer data would be helpful to estimate changes in cohort size structure. Absence of summer data hinders indexing YOY abundance in those species that recruit in spring, because under certain circumstances of water year type and weather, recruitment may occur late enough in some years that the timing of fixed-dates sampling would be inappropriate. The move to year-round sampling at least monthly in this program during the 1990s was a good step that will improve the usefulness of the data for status and trends monitoring of resident fishes. What sampling schedule is optimal for resident fishes is unclear at present (see recommendations below);

The geographical scope of the beach seine program is an advantage for resident fishes monitoring. While the station panel is heavily weighted toward Sacramento and San Joaquin River stations, it does capture a very useful upstream-downstream gradient, the more so since San Francisco Bay stations were re-occupied. Consequently, the program is able to capture spatial variation in the densities and timing of YOY appearance among resident and euryhaline species. What changes in the geographical scope of the program might benefit resident fishes monitoring is unclear at present (see recommendations below).

Because of the benefits described above, the beach seine program is likely to become part of a comprehensive fishes monitoring plan such as CALFED Bay-Delta Program's Comprehensive Monitoring, Assessment and Research Program (CMARP) (Randy Brown, personal communication). For the same reasons the program is a potentially valuable tool for restoration monitoring. For instance, the Prospect Island monitoring project, if it ever happens, will include seine sampling done expressly because the seining program exists for comparison. A reduction in the geographic scope or substantial reduction in the intensity of the seine program would probably degrade such uses.

2) Conclusions

The juvenile salmon monitoring beach seine program provides useful information for evaluating status and trends of delta-resident fish species, changes in the distribution of resident fish species, and for other research. The Chipps Island mid-water trawl is also useful for monitoring several non-salmonid species. At least ten IEP investigators are using or have recently used these data for studies of resident fishes. Furthermore, the beach seine program (at least) has been identified as a component of the CMARP fishes monitoring plan, which encompasses all delta fishes, not just salmonids.

3) Summary and Recommendations

In summary, the beach seine program could be altered without reducing its usefulness as a tool for monitoring resident fishes, but it would seem to be poor strategy to shrink it substantially, particularly by eliminating certain months of sampling or reducing the program's geographical scope. The beach seine program's combination of geographic scope and relatively long history are unique among delta fishes data-sets, and these features make it a valuable resource for research and especially status and trends monitoring of resident fishes.

The most important recommendation is that the beach seine program, at least, not be substantially reduced in either geographical scope or in seasonal coverage. Long time series of sampling data are very hard to come by, and reductions in the scope of sampling would probably have the highly undesirable effects of weakening available statistical inference (of trends) and might cause us to miss by chance crucial time periods or sampling locales where strong contrast in environmental variables would be very informative. It is important to maintain the present geographical coverage, possibly increasing the number of stations away from the river main-stems. It is unclear what changes would be best. It is also important to maintain the present coverage of months, and possibly increase the number of stations sampled year-round. Some reduction in sampling intensity (number of samples per month) would likely not be a problem at the core Sacramento River stations. It is unclear what changes would be best.

Some members of the Resident Fishes PWT (Randy Baxter, Kevin Fleming, Bill Harrell, Matt Nobriga, Lenny Grimaldo and Mike Chotkowski) have concluded that a group consultation that includes resident fishes persons and relevant CMARP participants (Randy Brown, Larry Brown, and Bill Bennett) would be appropriate as a means for distilling a recommendation regarding geographical or seasonal coverage. Such a consultation could occur in time for planning 2001 work.

It is recommended that the Delta Juvenile Salmon Monitoring Program be altered to explicitly include delta-resident fishes monitoring as a mission. If altered, the study should probably be jointly housed in the Resident Fishes PWT. This recommendation is based partly on the observation that there is relatively little communication between IEP salmon people and those studying other fishes, and more importantly because it seems essential that those investigating resident fishes be consulted before any major changes are made to the beach seine program.

The correct identification of non-salmonid fishes must be made a high priority. There is a general sense among people using the program's data that the quality of fish identifications has improved in recent years, but was questionable earlier. Special attention should be paid to ensuring that identifications of small fishes are correct. Some additional training and laboratory expense may be required to achieve this, and a cost-benefit calculation would be appropriate to decide how much additional expense is worthwhile. Any such calculation should involve resident fishes scientists.

It is also recommended that the program eliminate plus-counting, with the probable exception of inland silversides and threadfin shad. Use a better mechanism for sub-sampling the latter species, such as dipping a sub-sample out of a water-filled bucket containing the whole catch of that species.

Lastly, the program should retain questionable species and unusual specimens for lab examination. This would be useful not only as a means of quality-checking fish identifications, but also to help ensure that any unexpected species (such as new exotics) are unambiguously identified and preserved as vouchers as early as possible.

Summary and Recommendations

In general the salmon monitoring program appears to be meeting the three salmon monitoring objectives: indexing the long-term abundance and distribution of primarily fall-run salmon, determining the relative abundance and timing of other juvenile salmon races in the Delta, and monitoring when juvenile salmon enter the Delta during the fall months for managing water project operations. Minor modifications regarding reducing sampling (i.e. at Sacramento and Chipps Island in May and June from three days to two days per week) or increasing sampling (i.e. beach seining between October and March to two days per week) have been recommended. At times recommendations in the various sections are contradictory (i.e. reduction in the months sampled in the Bay for the salmon objectives and continue sampling in all months for the resident fish objectives). It is recommended that a comparison be conducted in the future between the mid-water and Kodiak trawl in December or January to verify that the Kodiak trawl is catching more of the larger juvenile salmon. Sampling at Mossdale has also been recommended year-round at three days a week, until it is established that juvenile salmon do not enter the Delta during the summer or fall months or are too scarce to effectively sample.

The additional beach seine and Kodiak trawling to meet the needs of water project operations, has generally been helpful, with some minor modifications suggested, such as reducing the number of additional beach seine stations sampled and the number of days sampled with the Kodiak trawl between mid-December and January 31 as the increased sampling after mid-December does not provide significantly more information. It is recommended that both Knights Landing rotary screw trap and Sacramento Kodiak trawl continue because they each provide important information on the timing and relative of abundance of all races of juvenile salmon in the lower River and Delta, respectively.

There is a recognized need to substantially increase monitoring efforts for Central Valley steelhead (CMARP Steering Committee 1999; IEP Steelhead Project Workteam 1999; Calfed ERPP 1999; McEwan, in prep). Given the spatial and temporal overlap of chinook salmon and steelhead that migrate into the estuary, a substantial increase in our knowledge of how steelhead utilize the estuary, and how Delta water project operations are affecting juvenile steelhead migration and rearing, could be accomplished with a modest increase in effort and funding. Sampling techniques to accomplish this include year-round beach seining at all entry locations into the Delta, Sacramento and Mossdale, and Chipps Island; and extending Kodiak trawling into April or May to completely cover the period when steelhead are moving into the Delta; Kodiak trawling is currently conducted between October 1 and March 31. One difficulty in implementing this recommendation is that during April and May (when traditionally the mid-water trawl is used) thousands of fall-run chinook salmon would be caught in the Kodiak trawl. Further discussions are needed with the ~~s~~Steelhead Project Work Team to resolve this difficulty. It is recommended that steelhead monitoring be incorporated into the objectives of the program, and to reflect this, the name of the program should be changed to Juvenile *Salmonid* Monitoring Program.

Input from scientists in the Delta regarding resident fish have encouraged the salmon monitoring program to incorporate resident fish monitoring objectives into the program and reflect this change by including non-salmonid biologists into the project work team or consulting others regarding changes to improve the program. Beach seining should not be decreased in either geographic or seasonal coverage to meet the objectives of monitoring resident fish. While it is acknowledged that it may be possible to alter the beach seine program without reducing its usefulness as a tool for monitoring resident fishes, it is not recommended to shrink it substantially.

To meet the salmon objectives in the future it is imperative that the baseline and expanded monitoring continue because it provides a means to assess potential changes in fisheries communities resulting from future recovery or restoration actions. Minor changes to the program have been recommended that would not limit, and potentially improve our ability to make these comparisons in the future. Specific changes and a more thorough sampling design for steelhead will need to be developed and is contingent upon input from the IEP Steelhead Project Work Team. To further address the future needs of juvenile salmon monitoring and research a review similar to this one is needed for the mark and recapture component of the juvenile salmon program in the Delta.

Literature Cited

CALFED 1999. Ecosystem Restoration Program Plan, Vol. 1. Ecological attributes of the San Francisco Bay-Delta watershed. Draft Programmatic EIS/EIR Tech. App. June 1999.

CMARP Steering Committee. 1999. Recommendations for the implementation and continued refinement of a comprehensive monitoring, assessment, and research program. 142 pp.

Brandes, P.L. and J. McLain, in press. Juvenile Chinook Salmon Abundance, Distribution and Survival in the Sacramento-San Joaquin Estuary. 2000

Fisher, F. W. 1992. Chinook salmon, *Oncorhynchus tshawytscha*, growth and occurrence in the Sacramento-San Joaquin river system. California Department of Fish and Game, Inland Fisheries Division, Red Bluff, California.

Hallock, R.J., W.F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (*Salmo gairdnerii gairdnerii*) in the Sacramento River system. Calif. Dept. Fish and Game Fish Bull. No. 114. 74 pp.

Hood, D.J. 1990. Fish Abundance, size and distribution in the Sacramento River near Hood, California in February and March, 1990.

Interagency Ecological Program (IEP) Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review of Existing Programs, and Assessment of Needs. *in* Comprehensive Monitoring, Assessment, and Research Program Plan, Tech. App. VII-A-11.

Interagency Ecological Program (IEP) Steelhead Project Work Team. 1998. Steelhead life-stage assessment protocol. 4 pp.

McEwan, D.R., Central Valley steelhead. in DFG Fish Bull. Proceedings of the Central Valley Salmonid Symposium, 1997. in prep.

Schaffter, R.G., 1980. Fish Occurrence, size and distribution in the Sacramento River near Hood, California during 1973 and 1974. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 80-3.

Snider, Bill., R. Titus. 1998. Evaluation of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing November 1995 – July 1996. Department of Fish and Game, Stream Evaluations Program, August 1998.

U.S. Fish and Wildlife Service 1987. Exhibit 31: The needs of chinook salmon, *Oncorhynchus tshawystcha* in the Sacramento-San Joaquin Estuary. Presented to the State Water Resources Control Board for the 1987 Water Quality/Water Rights Proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta.

U.S. Fish and Wildlife Service. 1990. 1990 Annual Progress Report: "Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary". Stockton, CA

U.S. Fish and Wildlife Service. 1993. 1992 Annual Progress Report: "Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary". Stockton, CA

U.S. Fish and Wildlife Service. 1994. 1993 Annual Progress Report: "Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary". Stockton, CA

U.S. Fish and Wildlife Service. 1997. 1994 Annual Progress Report: "Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary". Stockton, CA

U.S. Fish and Wildlife Service. 1998. 1995 Annual Progress Report: "Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary". Stockton, CA

U.S. Fish and Wildlife Service. 2000. 1996 Annual Progress Report: "Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary". Stockton, CA

Table 1: Detailed location, gear and frequency used to meet the three main objectives (table 2) of the juvenile salmon monitoring program between October 1, 1999 – September 30, 2000.

Site	Gear	Frequency	Duration	Objective
Sacramento	Kodiak Trawl	5 days/wk 3-4 days/wk	Oct 1 – Dec 31 Jan 1 – Mar 31	2/, 3/ 2/
Sacramento	Mid-water Trawl	3 days/wk 2-3 days/wk	Apr 1 – Jun 30 Jul 1 – Sep 30	1/ 2/
Sacramento	Beach seine	3 days/wk	Oct 15 – Jan 31	3/
Chipps Island	Mid-water Trawl	3 days/wk* 3 days/wk 2-3 days/wk	Oct 1 – Mar 31 Apr 1 – Jun 30 Jul 1 – Sep 30	2/ 1/ 2/
Mossdale	Kodiak Trawl	3 days/wk 3-7 days/wk	Oct 15 - Mar 31 Apr 1 – Jun 30	2/ Conducted by DFG Region 4
Lower Sac R.	Beach seine	1 day/wk 1 day/wk 1 day/wk 1 day/wk	Jan – Mar Apr-June July –September October – Dec	1/ 2/ 2/ 2/
North Delta	Beach seine	1 day/wk 1 day/wk 1 day/wk 1 day/wk	Jan – Mar Apr – June July –September October – Dec	1/ 2/ 2/ 2/
Central Delta	Beach seine	1 day/wk 1 day/wk 2 days/mo 2 days/mo	Jan – Mar April – June July –September October – Dec	1/ 2/ 2/ 2/
South Delta	Beach seine	1 day/wk 1 day/wk 2 days/mo 2 days/mo	Jan – March April – June July –September October – Dec	1/ 2/ 2/ 2/
San Joaquin R.	Beach seine	1 day/wk	Jan – Jun	2/
San Pablo/SF Bays	Beach seine	2 days/mo 2 days/mo 2 days/mo 2 days/mo	Jan – Mar April – June July –September October – Dec	1/ 2/ 2/ 2/

* Actual sampling is conducted more frequently to meet the needs of mark and recapture work funded by others.

Table 2: Breakout per program objective of the IEP Delta Salmon Monitoring Program for FY2000.

Objective #1 - Historical Monitoring

Program Element	Cost
Chipps Island (April-June) and Sacramento mid-water trawl (April-June), and Lower Sacramento River, Delta and bay seine	$100,543

Objective #2 - Expanded Monitoring

Program Element	Cost
Kodiak trawl at Mossdale (Oct. - March)	$ 58,956
Bay seine (April-Dec.)	25,259
San Joaquin River seine (Jan.-June)	21,567
Delta and Lower Sacramento River seine (April-Dec.)	78,783
Chipps Island mid-water trawl (Oct.-March)	44,130
Sacramento trawl (Oct.-March)	111,586
Chipps Island and Sacramento summer trawl (July-Sept.)	28,154
. . . . Total cost for Objective #2	$368,435

Objective #3 - Real Time Monitoring for Operational Decisions

Program Element	Cost
Sacramento seine (Oct.-Jan.) And Sacramento Kodiak trawl (Oct.-Dec., Additional 2 days/week)	$65,780

Additional Program Costs

Program Element	Cost
Program support and management salaries	$345,000

Total Program Costs (Objectives 1-3 + Additional Program Costs) $879,758

Table 3. North Delta Beach seine effort level, squared multiple R, probability value, and significance of regression models at four different effort intensities – historical density estimate.

Effort Level	Squared Multiple R	Probability Value	Significant ?
Four times per month (Full)	0.798	0.000007	Yes
Two Times per month (Half)-1st and 3rd monthly portions	0.689	0.000137	Yes
Two Times per month (Half)-2nd and 4th monthly portions	0.789	0.000010	Yes
One time per month (Quarter)	0.542	0.001741	Yes

Table 4. North Delta Beach Seine effort level, squared multiple R, probability value, and significance of regression models at four different effort intensities – ratio of means estimate.

Effort Level	Squared Multiple R	Probability Value	Significant ?
Four times per month (Full)	0.782	0.000012	Yes
Two Times per month (Half)-1st and 3rd monthly portions	0.613	0.000555	Yes
Two Times per month (Half)-2nd and 4th monthly portions	0.689	0.000128	Yes
One time per month (Quarter)	0.542	0.011359	Yes

Table 5. Effort Level, Squared Multiple R, Probability Value, and significance of regression models at three different effort intensities at Chipps Island between April 1 and June 30.

Effort Level	Squared Multiple R	Probability Value	Significant?
Full (three to seven days per week)	0.521	0.00015	Yes
Two days per week	0.438	0.00080	Yes
One day per week	0.365	0.00292	Yes

Table 6. Lower Sacramento River (top) and Delta (bottom) beach seine late-fall run raw catch, catch per cubic meter x's 100 (in parenthesis), and maximum monthly statistics for each year of between the 1993 and 1999 field seasons. Peak catch per cubic meter values are highlighted. Note that March-July migrants are fry and not included in the maximum monthly highlight. An average of the monthly means for all years is included in the last row of the table. NS = no sample

Lower Sacramento River

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1992 - 1993	NS	0	1 (0.030)	1 (0.070)	1 (0.090)	1 (0.040)	1 (0.030)	0	2 (0.260)	10 (0.370)	0	0	10 (0.370)
1993 - 1994	1 (0.034)	2 (0.021)	29 (0.405)	10 (0.079)	9 (0.128)	1 (0.013)	1 (0.085)	0	0	0	0	0	29 (0.405)
1994 - 1995	0	0	0	2 (0.027)	10 (0.438)	7 (0.502)	0	0	0	2 (0.126)	0	0	10 (0.502)
1995 - 1996	4 (0.091)	0	0	0	14 (0.403)	2 (0.105)	0	0	0	0	1 (0.038)	0	14 (0.403)
1996 - 1997	0	0	0	1 (0.014)	6 (0.545)	0	0	0	0	0	0	0	6 (0.545)
1997 - 1998	0	0	0	0	12 (0.825)	1 (0.032)	0	0	0	2 (0.300)	7 (0.769)	0	12 (0.825)
1998 - 1999	2 (0.001)	0	0	26 (0.021)	21 (0.012)	0	0	0	3 (0.005)	1 (0.003)	0	0	26 (0.021)

Delta

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1992 - 1993	NS	0	0	2 (0.0008)	1 (0.0004)	1 (0.0008)	0	0	0	0	6 (0.003)	NS	1 (0.0008)
1993 - 1994	NS	0	0	0	3 (0.0006)	3 (0.0007)	0	0	0	0	0	0	3 (0.0007)
1994 - 1995	0	0	0	1 (0.0001)	9 (0.0007)	4 (0.002)	1 (0.0001)	0	1 (0.0004)	3 (0.0005)	0	0	4 (0.002)
1995 - 1996	0	0	0	0	6 (0.0009)	2 (0.0003)	2 (0.001)	0	1 (0.0002)	7 (0.0006)	0	1 (0.0003)	2 (0.001)
1996 - 1997	0	0	0	3 (0.0002)	2 (0.0004)	1 (0.002)	0	0	1 (0.0002)	1 (0.001)	0	0	1 (0.002)
1997 - 1998	0	0	0	1 (0.0002)	7 (0.003)	0	0	0	18 (0.006)	4 (0.001)	10 (0.0006)	0	18 (0.006)
1998 - 1999	0	0	1 (0.0001)	13 (0.0037)	17 (0.0049)	2 (0.0013)	0	0	14 (0.0034)	3 (0.0006)	0	0	17 (0.0049)

Table 7. Lower Sacramento River (top) and Delta (bottom) beach seine winter run raw catch, catch per cubic meter x's 100 (in parenthesis), and maximum monthly statistics for each year 1993 and 1999 field seasons. Peak catch per cubic meter values are highlighted. An average of the monthly means for all years is included in the last row of the table. NS = no sample

Lower Sacramento River

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1992 - 1993	NS	2 (0.110)	0	15 (1.870)	18 (0.650)	52 (2.300)	30 (2.300)	0	0	0	0	0	52 (2.300)
1993 - 1994	0	0	2 (0.016)	0	5 (0.052)	7 (0.369)	12 (0.853)	0	0	0	0	0	12 (0.853)
1994 - 1995	0	0	0	7 (0.019)	2 (0.064)	53 (1.626)	4 (0.140)	12 (0.157)	0	0	0	0	53 (1.626)
1995 - 1996	0	0	0	0	119 (3.046)	45 (1.365)	14 (0.662)	4 (0.305)	1 (0.031)	0	0	0	119 (3.046)
1996 - 1997	0	0	0	0	34 (3.515)	0	7 (0.428)	4 (0.255)	0	0	0	0	34 (3.515)
1997 - 1998	0	0	0	36 (3.300)	48 (3.710)	48 (3.724)	0	0	0	0	0	0	48 (3.724)
1998 - 1999	0	1 (0.0027)	0	7 (0.1023)	115 (0.07131)	45 (0.0287)	14 (0.0192)	1 (0.00056)	0	0	0	0	7 (0.1023)

Delta

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1992 - 1993	NS	0	0	9 (0.003)	4 (0.001)	7 (0.006)	7 (0.003)	1 (0.0007)	0	0	0	NS	7 (0.006)
1993 - 1994	NS	0	0	0	0	0	2 (0.001)	0	0	0	0	0	2 (0.001)
1994 - 1995	0	0	0	0	0	6 (0.003)	4 (0.002)	1 (0.0002)	0	0	0	0	6 (0.003)
1995 - 1996	0	0	0	0	73 (0.011)	39 (0.006)	20 (0.007)	5 (0.001)	2 (0.0007)	0	0	0	73 (0.011)
1996 - 1997	0	0	0	1 (0.0005)	2 (0.0007)	1 (0.001)	2 (0.0006)	3 (0.0004)	0	0	0	0	1 (0.001)
1997 - 1998	0	0	0	5 (0.004)	42 (0.012)	9 (0.002)	1 (0.0005)	1 (0.0004)	0	0	0	0	42 (0.012)
1998 - 1999	0	4 (0.0005)	1 (0.0003)	53 (0.0155)	71 (0.0173)	13 (0.00203)	4 (0.00136)	7 (0.00136)	0	0	0	0	71 (0.0173)

Table 8. Lower Sacramento River (top) and delta (bottom) beach seine fall/spring run raw catch, catch per cubic meter x's 100 (in parenthesis), and maximum monthly statistics for each year of between the 1993 and 1999 field seasons. Peak catch per cubic meter values are highlighted. An average of the monthly means for all years is included in the last row of the table. NS = no sample

Lower Sacramento River

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1992 - 1993	NS	0	0	0	25 (0.157)	307 (0.228)	327 (0.413)	549 (0.332)	162 (0.055)	4 (0.006)	0	0	549 (0.332)
1993 - 1994	2 (0.007)	0	0	0	146 (0.064)	571 (0.121)	888 (0.639)	594 (0.485)	97 (0.017)	0	0	0	888 (0.639)
1994 - 1995	0	0	0	0	15 (0.009)	1,641 (2.193)	1,716 (1.837)	1,321 (1.511)	279 (0.369)	186 (0.191)	18 (0.022)	1 (0.005)	1,716 (1.837)
1995 - 1996	2 (0.0004)	0	0	0	1,028 (0.437)	2,345 (1.588)	3,854 (2.744)	2,043 (1.908)	282 (0.225)	46 (0.139)	0	1 (0.0002)	3,854 (2.744)
1996 - 1997	0	0	0	0	289 (0.200)	500 (1.624)	711 (0.945)	354 (0.566)	121 (0.076)	9 (0.006)	1 (0.004)	0	711 (0.945)
1997 - 1998	0	0	0	0	100 (0.219)	1,649 (1.371)	44 (0.139)	377 (0.457)	161 (0.326)	140 (0.366)	17 (0.018)	2 (0.055)	1,649 (1.371)
1998 - 1999	1 (0.0005)	0	0	3 (1.0639)	284 (0.1903)	1,293 (1.0326)	1,582 (2.5575)	2,985 (3.9546)	405 (0.7258)	56 (0.2763)	3 (0.00353)	2 (0.00206)	2,985 (3.9546)

Delta

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1992 - 1993	NS	0	0	0	11 (0.005)	156 (0.131)	283 (0.146)	756 (0.571)	1,048 (0.286)	98 (0.044)	17 (0.015)	NS	756 (0.571)
1993 - 1994	0	0	0	2 (0.0006)	12 (0.003)	119 (0.036)	1,943 (0.493)	582 (0.117)	115 (0.048)	24 (0.008)	3 (0.0001)	0	1,943 (0.493)
1994 - 1995	0	1 (0.0003)	0	0	16 (0.004)	3,357 (0.679)	3,394 (0.842)	4,716 (1.204)	1,132 (0.233)	265 (0.046)	27 (0.005)	1 (0.0002)	4,716 (1.204)
1995 - 1996	0	0	0	0	1,261 (0.133)	3,159 (0.448)	7,927 (1.669)	4,724 (0.834)	720 (0.135)	106 (0.022)	6 (0.001)	4 (0.002)	7,927 (1.669)
1996 - 1997	0	0	0	0	725 (0.182)	829 (0.409)	1,341 (0.474)	1,159 (0.299)	500 (0.110)	34 (0.019)	3 (0.0006)	0	1,341 (0.474)
1997 - 1998	1 (0.0002)	0	0	0	56 (0.016)	1,490 (0.481)	1,419 (0.419)	2,232 (0.595)	1,062 (0.247)	278 (0.069)	48 (0.008)	0	2,232 (0.595)
1998 - 1999	0	0	0	8 (0.0039)	308 (0.05797)	746 (0.1862)	2,801 (0.6295)	4,181 (1.0514)	1,287 (0.2519)	247 (0.0623)	22 (0.00447)	1 (0.00016)	4181 (1.0514)

Table 9. Lower Sacramento River, and Delta beach seine total catch per month of 70 - 150 mm chinook and catch per cubic meter (in parenthesis) between 1993 and 1999. NS = no sample.

Lower Sacramento River Seine (CPM^3 X 100)

Field season	Oct	Nov	Dec
1992 - 1993	1 (0.0494)	2 (0.0865)	19(0.874)
1993 - 1994	30 (0.416)	10 (0.0794)	14 (0.1801)
1994 - 1995	0	4 (0.0543)	9 (0.6943)
1995 - 1996	0	0	110 (3.936)
1996 - 1997	0	1 (0.0165)	40 (4.347)
1997 - 1998	0	45 (2.393)	52 (3.755)
1998 - 1999*	0	66 (10.985)	92 (7.34)

* = Princeton and Ord Bend no longer sampled by SSJEFRO.

Delta Seine (CPM^3 X 100)

Field season	Oct	Nov	Dec
1992 - 1993	0	6 (0.222)	2 (0.140)
1993 - 1994	0	2 (0.0514)	3 (0.0653)
1994 - 1995	0	1 (0.0059)	8 (0.0587)
1995 - 1996	0	0	58 (0.817)
1996 - 1997	0	9 (0.0509)	21 (0.763)
1997 - 1998	0	6 (0.111)	40 (0.633)
1998 - 1999	1 (0.011)	36 (0.928)	65 (1.156)

Table 10. Lower San Joaquin River beach seine fall run raw catch, catch per cubic meter x's 100 (in parenthesis), and maximum monthly statistics for each year between 1994 and 1999 field seasons. Peak means are highlighted. An average of the monthly means for all years is included in the last row of the table. NS = Not sampled

Field season	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1993 - 1994	0	0	0	44 (1.989)	0	0	NS	44 (1.989)
1994 - 1995	0	14 (1.510)	18 (0.970)	0	1 (0.0022)	2 (0.0077)	NS	14 (1.510)
1995 - 1996	0	2 (0.365)	1 (0.116)	6 (1.0556)	0	0	NS	6 (1.0556)
1996 - 1997	0	0	27 (4.9245)	17 (2.254)	0	0	NS	27 (4.9245)
1997 - 1998	82 (5.0803)	36 (55.0)	88 (19.98)	43 (3.901)	7 (0.8398)	0	NS	36 (55.0)
1998 - 1999	83 (13.037)	563 (56.19)	279 (24.922)	363 (17.923)	13 (1.0322)	2 (0.232)	NS	563 (56.19)

Table 11. Sacramento River midwater and Kodiak trawl late-fall run raw catch, catch per cubic meter X's 10,000 (in parenthesis), and maximum monthly statistics for each year between 1994 and 1999 field seasons. Peak catch per cubic meter values are highlighted. An average of the monthly means for all years is included in the last row of the table. NS = Not sampled.

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1993 - 1994 mwtr	NS	4 (0.155)	19 (0.207)	1 (0.0049)	4 (0.0476)	1 (0.0104)	2 (0.0197)	0	0	0	0	NS	19 (0.207)
1994 - 1995 mwtr*	NS	0	0	1 (0.011)	30 (0.332)	NS	NS	0	0	0	0	1 (0.016)	30 (0.332)
1994 - 1995 kdtr*	NS	NS	NS	NS	2 (0.048)	8 (0.153)	0	0	0	NS	NS	NS	8 (0.153)
1995 - 1996 mwtr	1 (0.0159)	1 (0.0125)	0	NS	NS	NS	NS	NS	1 (0.0057)	0	0	0	1 (0.0159)
1995 - 1996 kdtr	NS	NS	0	0	17 (0.0704)	10 (0.0427)	0	0	0	NS	NS	NS	17 (0.0704)
1996 - 1997 mwtr	0	0	0	NS	NS	2 (0.0639)	0	0	0	0	0	0	2 (0.0639)
1996 - 1997 kdtr	NS	NS	0	8 (0.0453)	8 (0.0388)	1 (0.150)	1 (0.0162)	0	NS	NS	NS	NS	1 (0.150)
1997 - 1998 mwtr	5 (0.0901)	3 (0.0689)	2 (0.0783)	NS	NS	NS	NS	0	1 (0.0193)	0	1 (0.0122)	NS	5 (0.0901)
1997 - 1998 kdtr	NS	NS	0	16 (0.096)	5 (0.0441)	0	0	0	NS	NS	NS	NS	16 (0.096)
1998 - 1999 mwtr	NS	NS	NS	NS	1 (0.0939)	NS	NS	0	3 (0.0207	0	0	0	1 (0.0939)
1998 - 1999 kdtr	NS	0	1 (0.0069)	16 (0.158)	7 (0.0557)	0	0	0	NS	NS	NS	NS	16 (0.158)

* = partial effort during December and January

Table 12. Sacramento River midwater and Kodiak trawl winter run raw catch, catch per cubic meter x's 10,000 (in parenthesis), and maximum monthly statistics for each year between 1994 and 1999 field seasons. Peak catch per cubic meter values are highlighted (Kodiak trawl only). An average of the monthly means for all years is included in the last row of the table. NS = Not sampled.

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1993 - 1994 mwtr	NS	0	0	0	0	0	8 (0.0839)	2 (0.0235)	5 (0.0536)	0	0	NS	8 (0.0839)
1994 - 1995 mwtr	NS	0	0	0	0	NS	NS	15 (0.334)	10 (0.281)	0	0	0	15 (0.334)
1994 - 1995 kdtr	NS	NS	NS	NS	1 (0.026)	3 (0.054)	40 (0.292)	35 (0.892)	46 (0.356)	NS	NS	NS	35 (0.892)
1995 - 1996 mwtr	0	0	0	NS	NS	NS	NS	NS	2 (0.0113)	0	0	0	2 (0.0113)
1995 - 1996 kdtr	NS	NS	0	0	61 (0.249)	31 (0.142)	31 (0.170)	120 (0.723)	3 (0.605)	NS	NS	NS	120 (0.723)
1996 - 1997 mwtr	0	0	0	NS	NS	0	2 (0.0407)	0	2 (0.0130)	0	0	0	2 (0.0407)
1996 - 1997 kdtr	NS	NS	0	2 (0.0161)	8 (0.0338)	0	13 (0.213)	18 (0.117)	NS	NS	NS	NS	13 (0.213)
1997 - 1998 mwtr	0	0	0	NS	NS	NS	NS	0	5 (0.0820)	0	0	NS	5 (0.0820)
1997 - 1998 kdtr	NS	NS	0	10 (0.0763)	9 (0.0882)	2 (0.0151)	3 (0.0694)	33 (0.233)	NS	NS	NS	NS	33 (0.233)
1998 - 1999 mwtr	NS	NS	NS	NS	6 (0.5316)	NS	NS	2 (0.0820)	1 (0.0074)	0	0	0	6 (0.5316)
1998 - 1999 -kdtr	NS	0	2 (0.011)	57 (0.6778)	16 (0.1272)	6 (0.0628)	3 (0.0365)	11 (0.1057)	NS	NS	NS	NS	57 (0.6778)

Table 13. Sacramento River midwater and Kodiak trawling fall/spring run raw catch, catch per cubic meter X's 10,000 (in parenthesis), and maximum monthly statistics for each year between 1994 and 1998 field seasons. Peak catch per unit effort values are highlighted. An average of the monthly means for all years is included in the last row of the table. NS = Not sampled.

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1993 - 1994 mwtr	NS	1 (0.0416)	0	1 (0.0074)	4 (0.0749)	192 (1.994)	1,036 (10.949)	69 (0.850)	6,588 (109.398)	2,425 (27.448)	73 (1.648)	NS	6,588 (109.398)
1994 -1995 mwtr	NS	0	0	0	6 (0.069)	NS	NS	1,020 (23.030)	648 (14.782)	2,312 (13.882)	289 (4.382)	20 (0.261)	1,020 (23.030)
1994 - 1995 kdtr	NS	NS	NS	NS	0	1,132 (18.884)	1,168 (7.581)	2,324 (58.794)	1,366 (9.675)	NS	NS	NS	2,324 (58.794)
1995 - 1996 mwtr	6 (0.0725)	0	0	NS	NS	NS	NS	NS	5,767 (44.184)	5,493 (31.515)	62 (2.344)	13 (0.229)	5,767 (44.184)
1995 - 1996 kdtr	NS	NS	NS	NS	669 (2.529)	7,456 (35.258)	21,044 (122.547)	2,802 (168.238)	2,111 (512.389)	NS	NS	NS	2,111 (512.389)
1996 - 1997 mwtr	0	1 (0.0129)	0	NS	NS	46 (1.726)	47 (0.935)	9 (1.674)	5,886 (51.84)	1,451 (13.56)	59 (0.881)	30 (0.576)	5,886 (51.84)
1996 - 1997 kdtr	NS	NS	0	2 (0.014)	191 (1.599)	117 (20.36)	242 (4.18)	407 (2.711)	NS	NS	NS	NS	117 (20.36)
1997 - 1998 mwtr	10 (0.161)	1 (0.0189)	0	NS	NS	NS	NS	22 (7.347)	1,734 (25.49)	1,061 (15.53)	671 (7.78)	NS	1,734 (25.49)
1997 - 1998 kdtr	NS	NS	0	2 (0.0115)	37 (0.274)	3,211 (89.64)	1,530 (53.79)	1,260 (12.73)	NS	NS	NS	NS	3,211 (89.64)
1998 - 1999 mwtr	NS	NS	NS	NS	0	NS	NS	39 (6.927)	3,599 (33.945)	3,187 (58.392)	140 (2.0148)	10 (0.1534)	3,187 (58.392)
1998 - 1999 kdtr	NS	0	0	1 (0.00927)	12 (0.1309)	1,480 (14.02)	3,248 (42.532)	557 (4.571)	NS	NS	NS	NS	3,248 (42.532)

Table 14. Sacramento River Kodiak and midwater trawl total catch per month of 70 - 150 mm chinook and catch per cubic meter (in parenthesis) between 1993 and 1999. NS = no sample.

Sacramento River Kodiak Trawl
(CPM^3 X 10,000)

Field season	Oct	Nov	Dec
1992 -1993	NS	NS	NS
1993 -1994	NS	NS	NS
1994 -1995	NS	NS	3 (0.00742)
1995 -1996	0	0	65 (0.269)
1996 -1997	0	9 (0.0528)	14 (0.0637)
1997 -1998	0	22 (0.134)	12 (0.110)
1998 -1999	1 (0.00688)	50 (0.578)	20 (0.165)

Sacramento River Midwater Trawl
(CPM^3 X 10,000)

Field season	Oct	Nov	Dec
1992 -1993	0	46 (NA)	8 (NA)
1993 -1994	19 (0.0781)	2 (0.00468)	4 (0.0193)
1994 -1995	0	1 (0.0440)	28 (0.153)
1995 -1996	0	NS	NS
1996 -1997	0	NS	NS
1997 -1998	1 (0.0317)	NS	NS
1998 -1999*	NS	NS	5(0.0556)

* = Occasional sampling between Oct 1 and Dec 31.

NA = volume information was not taken, therefore CPM^3 could not be calculated.

Table15. Mossdale Kodiak trawl fall run raw catch, catch per cubic meter X's 10,000 (in parenthesis), and maximum monthly statistics for each year between 1997 and 1999 field seasons. Peak means are highlighted. An average of the monthly means for all years is included in the last row of the table.

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1996 - 1997	NS	0	0	0	0	NS	NS	30 (0.72)	800 (2.923)	656 (4.019)	110 (1.193)	NS	656 (4.019)
1997 - 1998	NS	NS	NS	NS	NS	NS	NS	NS	504 (2.214)	1261 (3.115)	551 (0.494)	NS	1261 (3.115)
1998 - 1999	NS	NS	NS	0	0	81 (0.96)	319 (3.94)	84 (0.68)	264 (1.19)	406 (2.3)	183 (1.383)	NS	406 (2.3)

NS = Not sampled

Prior to 1997, sampling at Mossdale occurred between April and June, conducted by DFG, Region 4.

Table 16. Chipps Island midwater trawl late-fall run raw catch, catch per cubic meter X's 10,000 (in parenthesis), and maximum monthly statistics for each year between 1994 and 1999 field seasons. Peak catch per cubic meter values are highlighted. An average of the monthly means for all years is included in the last row of the table. NS = Not sampled.

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1993 - 1994	NS	NS	NS	8 (0.030)	53 (0.0789)	2 (0.005)	5 (0.0134)	0	0	0	0	NS	53 (0.0789)
1994 - 1995	NS	NS	0	5 (0.023)	49 (0.0725)	34 (0.0399)	0	0	0	1 (0.001)	0	0	49 (0.0725)
1995 - 1996	0	1 (0.0063)	1 (0.0154)	0	10 (0.184)	20 (0.0394)	1 (0.0022)	0	0	1 (0.0046)	0	0	10 (0.184)
1996 - 1997	0	NS	0	0	74 (0.112)	12 (0.0219)	0	0	0	0	0	0	74 (0.112)
1997 - 1998	5 (0.0151)	6 (0.0506)	6 (0.0196)	5 (0.031)	49 (0.0831)	12 (0.0109)	0	0	0	0	0	NS	49 (0.0831)
1998 - 1999	NS	12 (0.0575)	0	25 (0.378)	53 (0.0879)	4 (0.00762)	1 (0.00331)	0	0	0	0	1 (0.012)	25 (0.378)

Table 17. Chipps Island midwater trawl winter run raw catch, catch per cubic meter X's 10,000 (in parenthesis), and maximum monthly statistics for each year between 1994 and 1999 field seasons. Peak catch per cubic meter values are highlighted (Kodiak trawl only). An average of the monthly means for all years is included in the last row of the table. NS = Not sampled.

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1993 - 1994	NS	NS	NS	0	0	1 (0.0027)	2 (0.0112)	29 (0.083)	14 (0.0207)	1 (0.001)	0	NS	29 (0.083)
1994 - 1995	NS	NS	0	0	0	10 (0.0115)	38 (0.325)	109 (0.437)	151 (0.332)	4 (0.0042)	0	0	109 (0.437)
1995 - 1996	0	0	0	0	4 (0.064)	38 (0.0655)	33 (0.112)	239 (0.595)	39 (0.0858)	3 (0.0012)	0	0	239 (0.595)
1996 - 1997	0	NS	0	0	1 (0.009)	11 (0.0168)	33 (0.0816)	72 (0.253)	44 (0.129)	2 (0.0025)	0	0	72 (0.253)
1997 - 1998	0	0	0	0	6 (0.01)	17 (0.026)	4 (0.0177)	54 (0.217)	29 (0.0621)	2 (0.0029)	0	NS	54 (0.217)
1998 - 1999	NS	0	0	0	12 (0.197)	7 (0.0115)	18 (0.0863)	64 (0.278)	55 (0.102)	0	0	0	64 (0.278)

Table 18. Chipps Island midwater trawl fall/spring run raw catch, catch per cubic meter X's 10,000 (in parenthesis), and maximum monthly statistics for each year between 1994 and 1998 field seasons. Peak catch per unit effort values are highlighted. An average of the monthly means for all years is included in the last row of the table. NS = Not sampled.

Field season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Max
1993 - 1994	NS	NS	NS	11 (0.331)	0	0	1 (0.003)	5 (0.0171)	3,713 (4.439)	2,094 (3.740)	102 (0.195)	NS	3,713 (4.439)
1994 - 1995	NS	NS	15 (0.057)	9 (0.036)	0	457 (0.572)	125 (0.407)	262 (1.134)	4,179 (7.779)	11,423 (15.393)	3,178 (0.511)	100 (0.345)	11,423 (15.393)
1995 - 1996	14 (0.0324)	8 (0.068)	15 (0.193)	1 (0.0131)	2 (0.031)	59 (0.100)	1,578 (3.661)	688 (1.590)	4,233 (9.356)	10,195 (13.577)	339 (1.508)	0	10,195 (13.577)
1996 - 1997	2 (0.141)	NS	0	1 (0.0113)	7 (0.017)	31 (0.817)	2 (0.004)	27 (0.123)	2,351 (3.912)	1,323 (2.358)	187 (0.358)	26 (0.103)	2,351 (3.912)
1997 - 1998	10 (0.0473)	3 (0.013)	1 (0.0034)	0	1 (0.0015)	209 (0.336)	138 (0.678)	568 (2.735)	10,929 (10.71)	20,377 (16.28)	1,711 (3.62)	NS	20,377 (16.28)
1998 - 1999	NS	10 (0.053)	4 (0.0283)	0	0	22 (0.0412)	194 (1.171)	124 (0.507)	3,828 (4.676)	9,153 (9.923)	866 (2.211)	3 (0.127)	9153 (9.923)

Table 19. Chipps Island midwater trawl total catch per month of 70 - 150 mm chinook and catch per cubic meter x's 10,000 (in parenthesis), between 1993 and 1999.

Field season	Oct	Nov	Dec
1992 - 1993	0	0	0
1993 - 1994	0	10 (0.0332)	43 (0.0647)
1994 - 1995	2 (0.00596)	1 (0.0044)	67 (0.08)
1995 - 1996	7 (0.0635)	0	24 (0.471)
1996 - 1997	0	6 (0.0626)	87 (0.112)
1997 - 1998	8 (0.0275)	12 (0.088)	61 (0.118)
1998 - 1999	2 (0.0191)	25 (0.387)	64 (0.108)

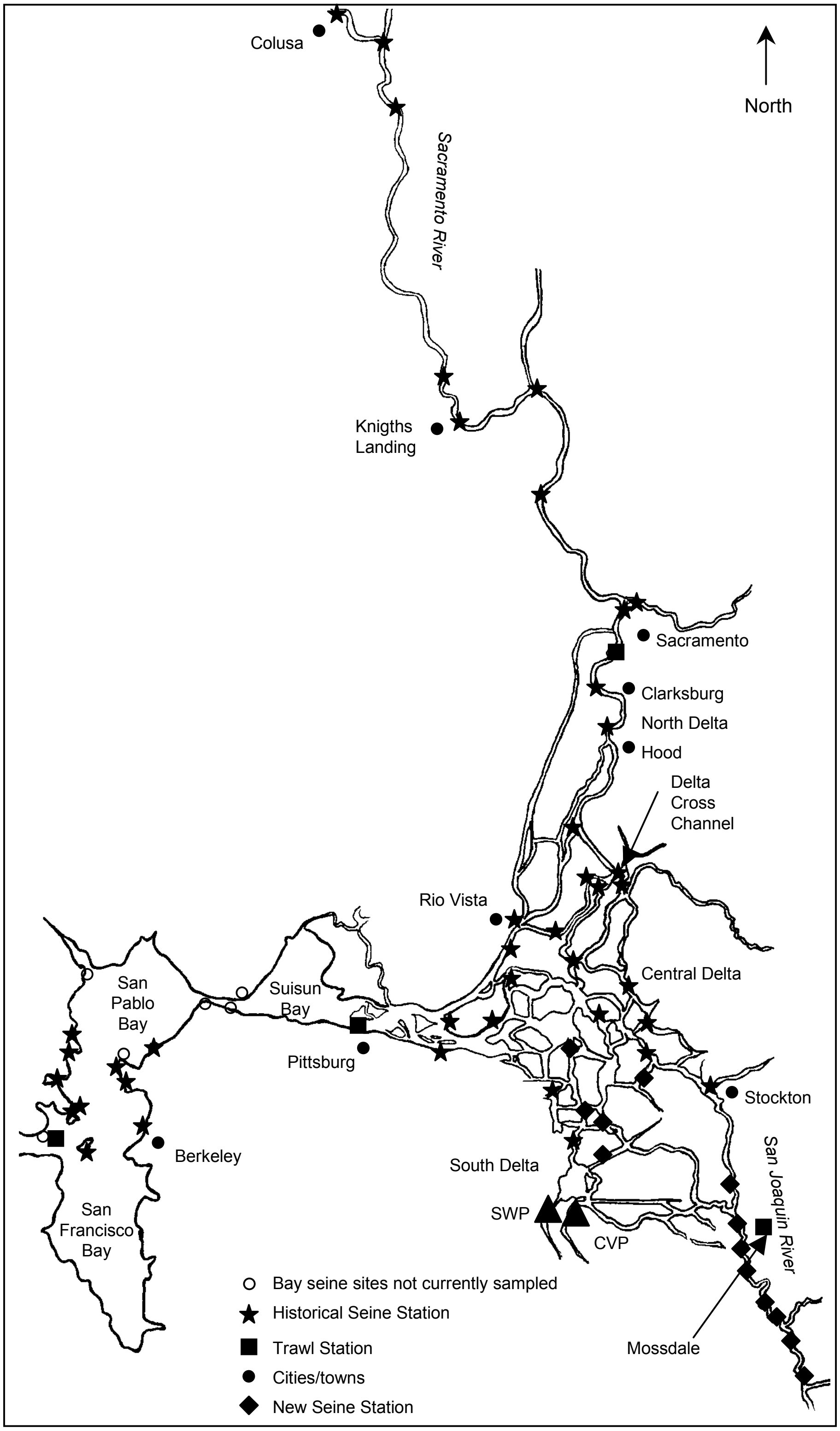


FIGURE 1: Beach seine and trawling locations in the Sacramento-San Joaquin Estuary included as part of the juvenile salmon monitoring program.

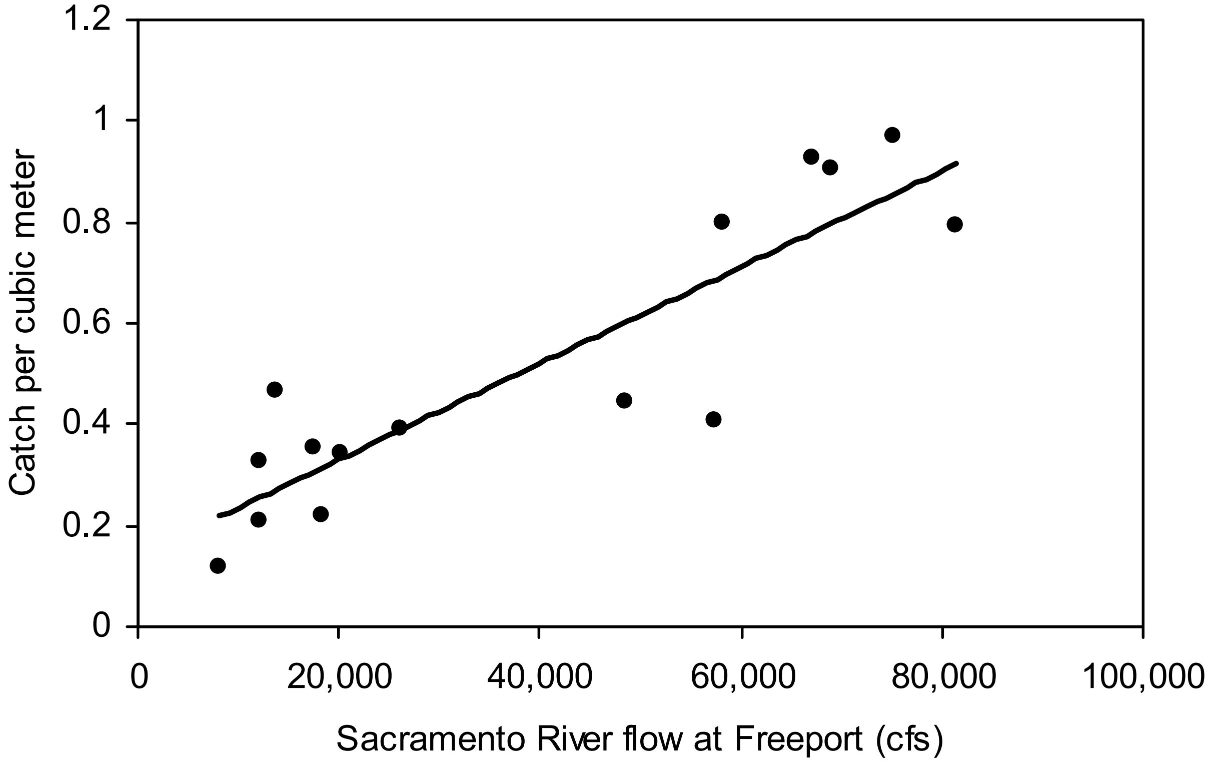


FIGURE 2. Mean catch of chinook fry between January 1 and March 31 in the North Delta beach seine regressed with mean February flow at Freeport. **FULL EFFORT (FOUR TIMES PER MONTH)**

>MODEL FULLEFFORT = CONSTANT+FEBFLOW

Dep Var: FULLEFFORT N: 15 Multiple R: 0.8931837 Squared multiple R: 0.7977771

Adjusted squared multiple R: 0.7822215 Standard error of estimate: 0.1356566

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.1400416	0.0633511	0.0	.	2.21056	0.04560
FEBFLOW	0.0000097	0.0000014	0.8931837	1.00E+00	7.16139	0.00001

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.9437924	1	0.9437924	51.2855118	0.0000074
Residual	0.2392352	13	0.0184027		

*** WARNING ***
Case 13 is an outlier (Studentized Residual = -2.7519286)

Durbin-Watson D Statistic 2.233
First Order Autocorrelation -0.174

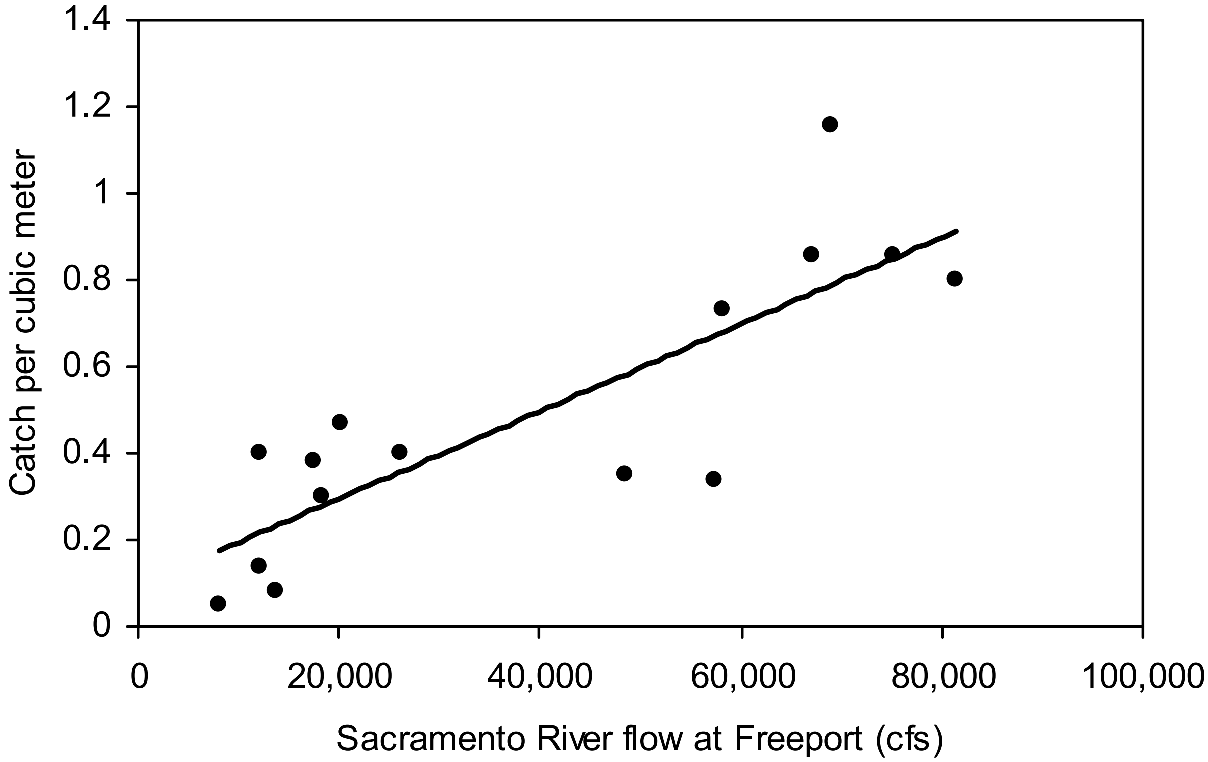


FIGURE 3. Mean catch of chinook fry between January 1 and March 31 in the North Delta beach seine regressed with mean February flow at Freeport. **HALF EFFORT (FIRST AND THIRD PORTIONS)**

```
>MODEL FIRSTHIRW = CONSTANT+FEBFLOW

Dep Var: FIRSTHIRW   N: 15   Multiple R: 0.8282787   Squared multiple R: 0.6860455

Adjusted squared multiple R: 0.6618952   Standard error of estimate: 0.1879692

Effect        Coefficient    Std Error     Std Coef Tolerance     t   P(2 Tail)

CONSTANT        0.0987095    0.0877809    0.0         .        1.12450  0.28114
FEBFLOW         0.0000100    0.0000019    0.8282787  1.00E+00  5.32985  0.00014

                    Analysis of Variance

Source          Sum-of-Squares   df  Mean-Square    F-ratio      P

Regression          1.0036983     1    1.0036983  28.4072788   0.0001367
Residual            0.4593217    13    0.0353324
-------------------------------------------------------------------------------

*** WARNING ***
Case          2 is an outlier       (Studentized Residual =    2.5618847)

Durbin-Watson D Statistic     1.728
First Order Autocorrelation   0.128
```

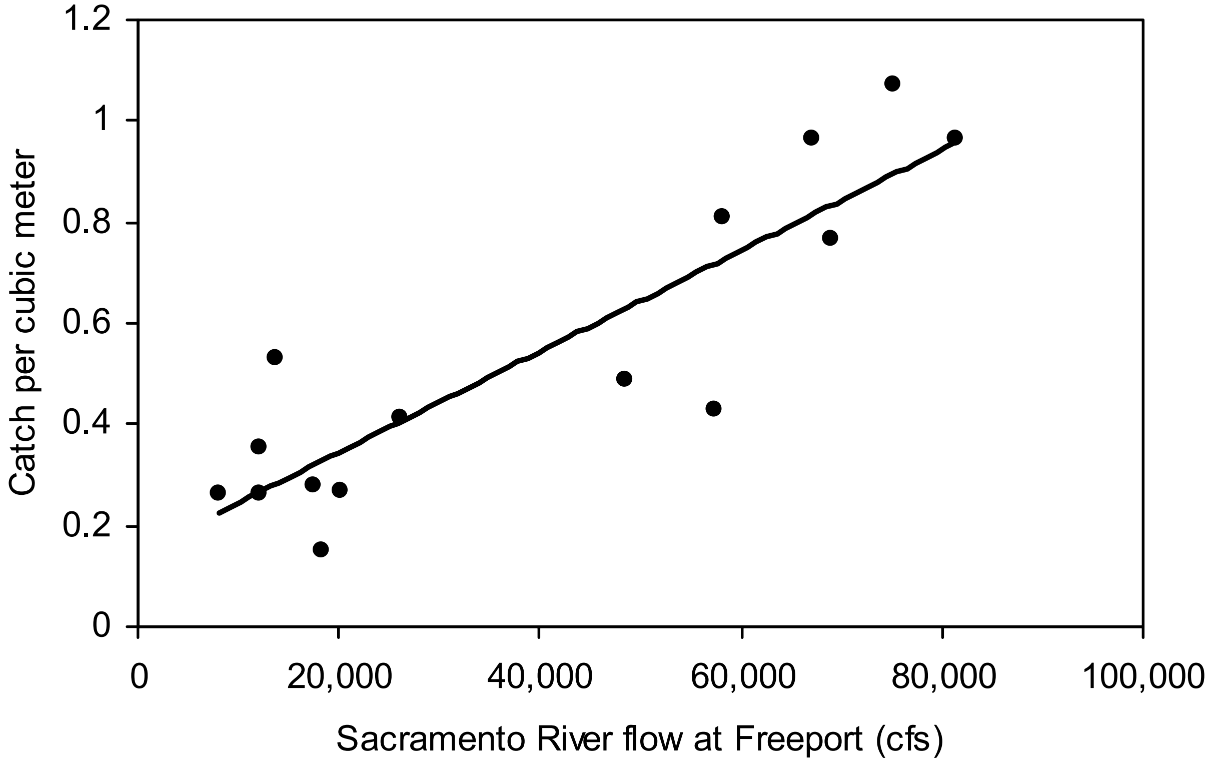


FIGURE 4. Mean catch of chinook fry between January 1 and March 31 in the North Delta beach seine regressed with mean February flow at Freeport. **HALF EFFORT (SECOND AND FOURTH PORTIONS)**

>MODEL SECFOUW = CONSTANT+FEBFLOW

Dep Var: SECFOUW N: 15 Multiple R: 0.8882507 Squared multiple R: 0.7889892

Adjusted squared multiple R: 0.7727576 Standard error of estimate: 0.1459738

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.1433116	0.0681692	0.0	.	2.10229	0.05558
FEBFLOW	0.0000102	0.0000015	0.8882507	1.00E+00	6.97196	0.00001

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1.0357606	1	1.0357606	48.6082326	0.0000097
Residual	0.2770084	13	0.0213083		

Durbin-Watson D Statistic 1.721
First Order Autocorrelation 0.048

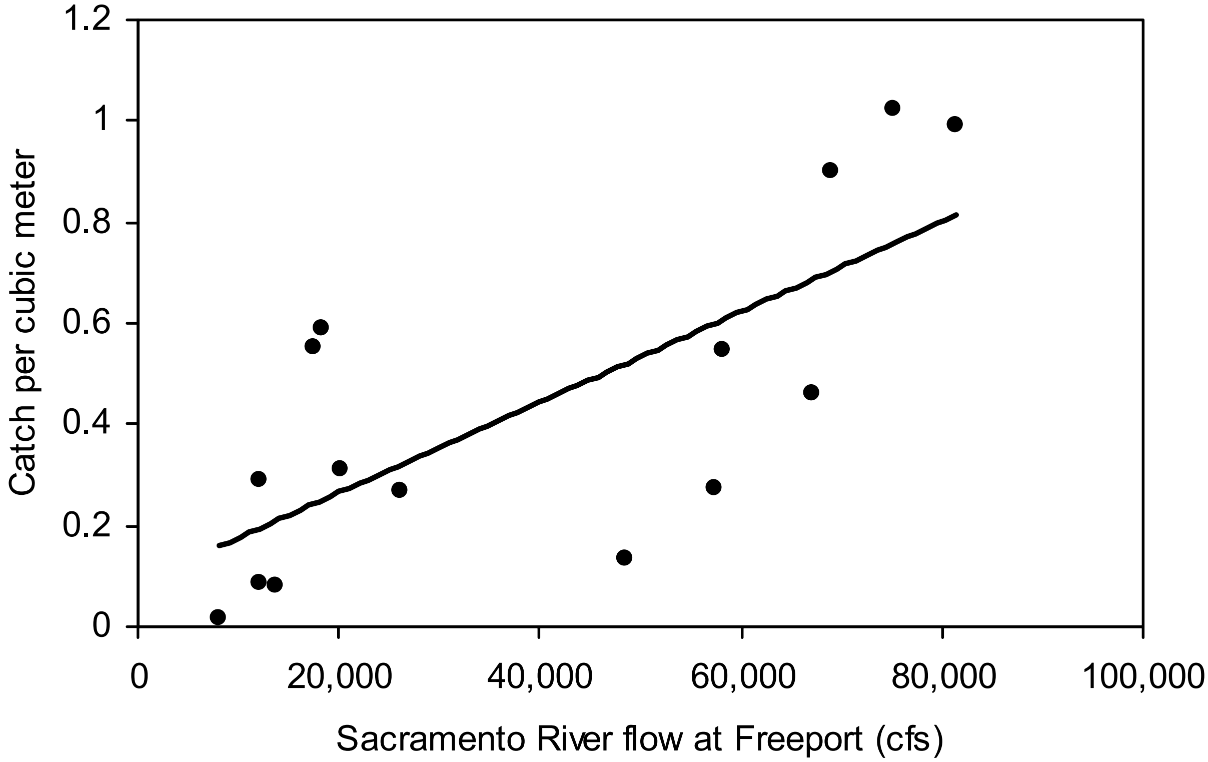


FIGURE 5. Mean catch of chinook fry between January 1 and March 31 in the North Delta beach seine regressed with mean February flow at Freeport. **QUARTER EFFORT (FIRST PORTION OF THE MONTH ONLY)**

>MODEL FIRSTWEEK = CONSTANT+FEBFLOW

Dep Var: FIRSTWEEK N: 15 Multiple R: 0.7364651 Squared multiple R: 0.5423809

Adjusted squared multiple R: 0.5071794 Standard error of estimate: 0.2444252

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.0763123	0.1141456	0.0	.	0.66855	0.51548
FEBFLOW	0.0000096	0.0000024	0.7364651	1.00E+00	3.92529	0.00174

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.9205248	1	0.9205248	15.4079037	0.0017409
Residual	0.7766678	13	0.0597437		

Durbin-Watson D Statistic 2.014
First Order Autocorrelation -0.127

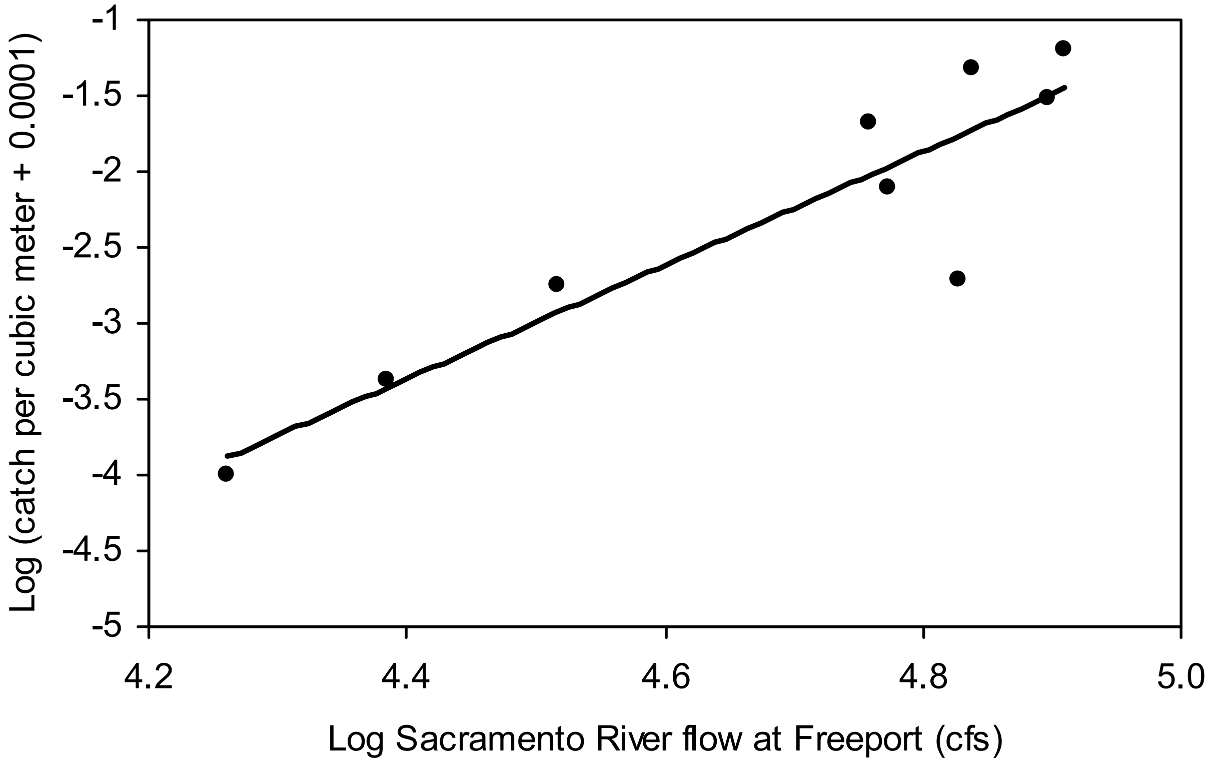


FIGURE 6. Log + .0001 of mean catch of chinook fry between January 1 and March 31 in the San Francisco Bay beach seine regressed with log of mean February flow at Freeport between 1981 and 1986, and 1997 and 1999. **FULL EFFORT (ONE TO TWO TIMES PER MONTH)**

>MODEL LOGFLOW = CONSTANT+LOGALL

Dep Var: LOGFLOW N: 9 Multiple R: 0.9088127 Squared multiple R: 0.8259405

Adjusted squared multiple R: 0.8010748 Standard error of estimate: 0.1058314

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	5.1922283	0.0947267	0.0	.	54.81270	0.00000
LOGALL	0.2205744	0.0382720	0.9088127	1.00E+00	5.76334	0.00069

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.3720301	1	0.3720301	33.2161239	0.0006889
Residual	0.0784020	7	0.0112003		

*** WARNING ***
Case 9 is an outlier (Studentized Residual = 5.1464075)

Changed scale made figure different than in report - PLB

Durbin-Watson D Statistic 1.152
First Order Autocorrelation 0.046

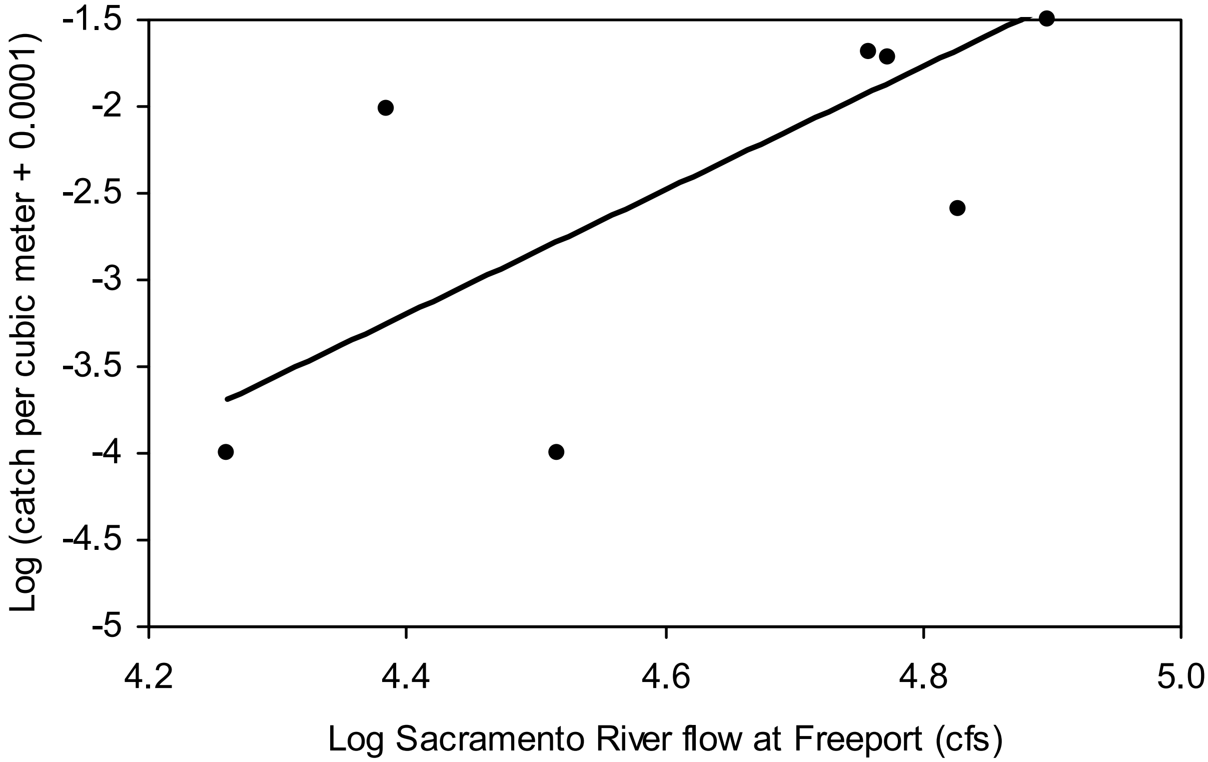


FIGURE 7. Log + .0001 of mean catch of chinook fry during February in the San Francisco Bay beach seine regressed with log of mean February flow at Freeport between 1981 and 1986, and 1997 and 1999. **FEBRUARY ONLY**

```
>MODEL LOGFLOW = CONSTANT+LOGFEB

Dep Var: LOGFLOW   N: 9   Multiple R: 0.7426772   Squared multiple R: 0.5515694

Adjusted squared multiple R: 0.4875078   Standard error of estimate: 0.1698687

Effect        Coefficient    Std Error     Std Coef Tolerance     t   P(2 Tail)

CONSTANT        5.0200914    0.1272961    0.0        .        39.43635  0.00000
LOGFEB          0.1539982    0.0524825    0.7426772  1.00E+00  2.93428  0.02189

                     Analysis of Variance

Source          Sum-of-Squares   df  Mean-Square     F-ratio       P

Regression          0.2484445     1    0.2484445   8.6099951   0.0218906
Residual            0.2019875     7    0.0288554
---------------------------------------------------------------------------

*** WARNING ***
Case          1 is an outlier       (Studentized Residual =   -2.9522299)

Durbin-Watson D Statistic     1.117
First Order Autocorrelation   0.074
```

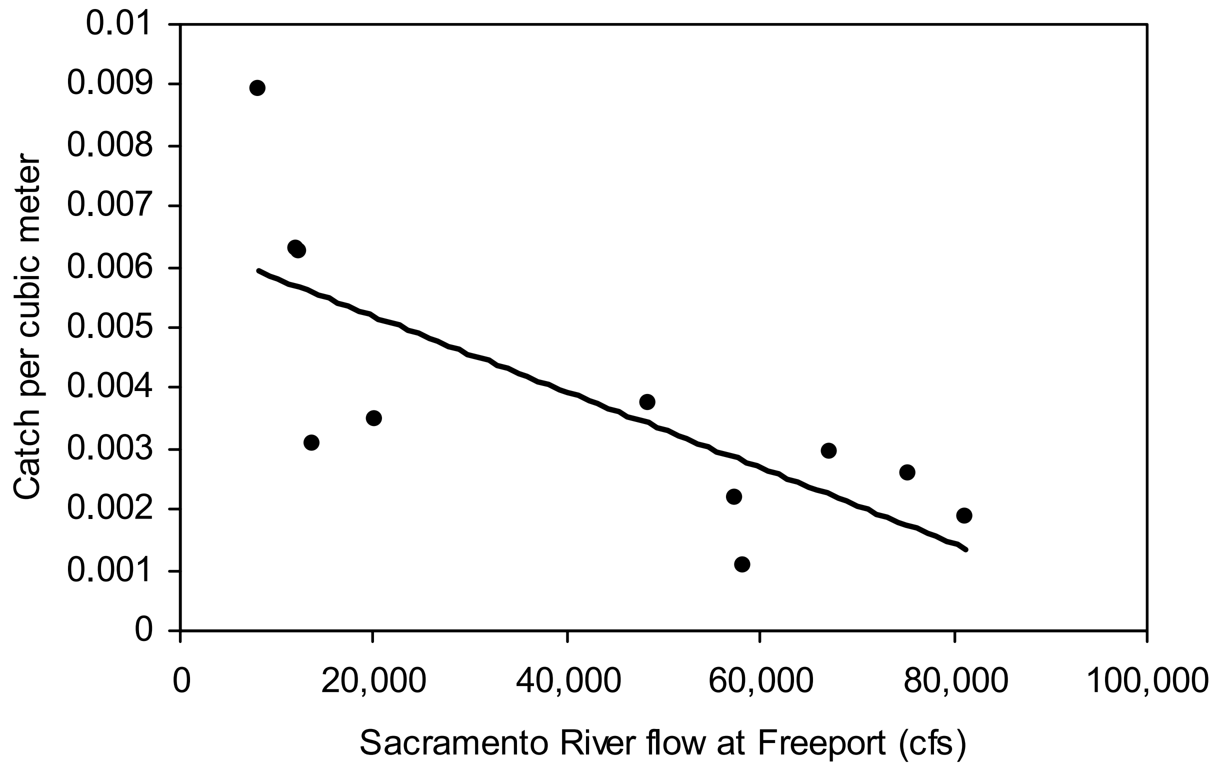


FIGURE 8. Mean catch of chinook smolts between April 1 and June 30 in the midwater trawl at Sacramento regressed with mean flow at Freeport between April 1 and June 30. **FULL EFFORT (APPROXIMATELY 3 DAYS/WEEK)**

>MODEL FULLCPM = CONSTANT+FLOW

Dep Var: FULLCPM N: 11 Multiple R: 0.7520601 Squared multiple R: 0.5655945

Adjusted squared multiple R: 0.5173272 Standard error of estimate: 0.0016320

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.0064317	0.0008989	0.0	.	7.15516	0.00005
FLOW	-0.0000001	0.0000000	-0.7520601	1.00E+00	-3.42315	0.00759

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.0000312	1	0.0000312	11.7179677	0.0075900
Residual	0.0000240	9	0.0000027		

*** WARNING ***
Case 4 is an outlier (Studentized Residual = 2.7799131)

Durbin-Watson D Statistic 2.577
First Order Autocorrelation -0.305

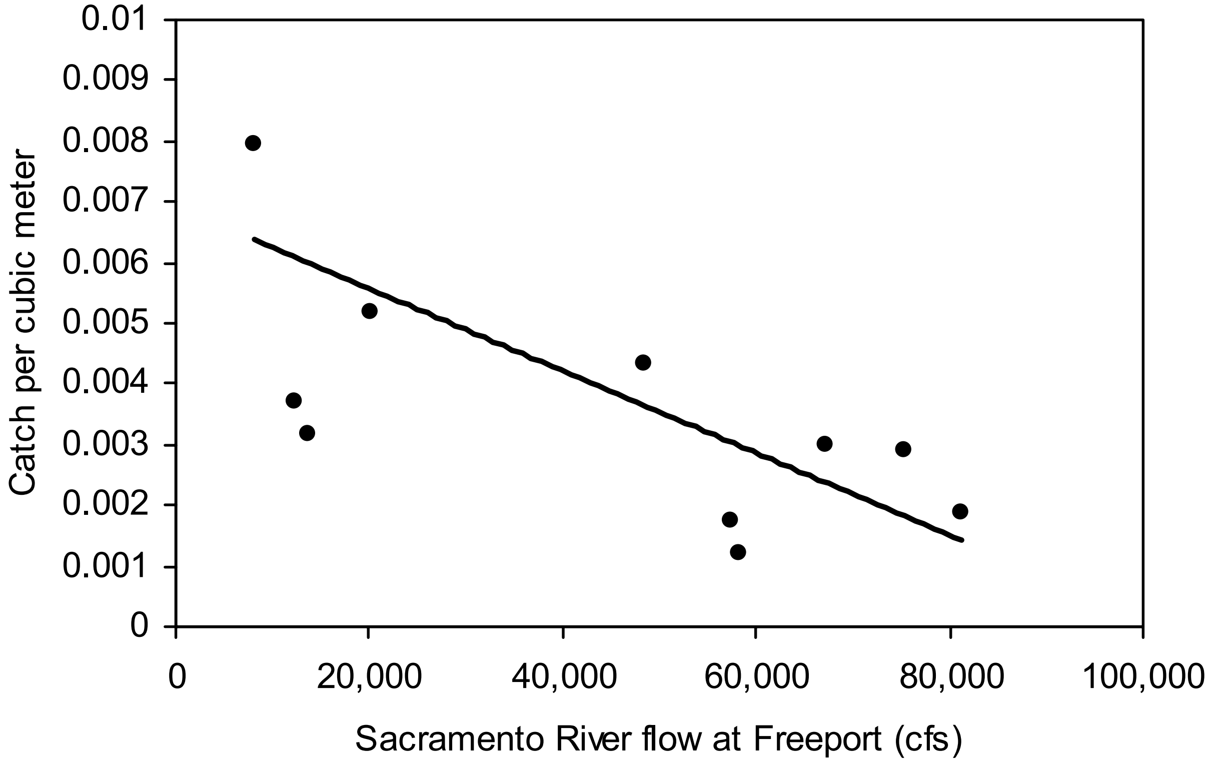


FIGURE 9. Mean catch of chinook smolts between April 1 and June 30 in the midwater trawl at Sacramento regressed with mean February flow at Freeport. **TWO DAYS PER WEEK**

```
>MODEL FLOW = CONSTANT+TWODAYCPM

Dep Var: FLOW   N: 11   Multiple R: 0.6838473   Squared multiple R: 0.4676472

Adjusted squared multiple R: 0.4084969   Standard error of estimate: 2.17897E+04

Effect        Coefficient    Std Error    Std Coef Tolerance     t   P(2 Tail)

CONSTANT       6.97699E+04  1.20707E+04   0.0        .        5.78009  0.00027
TWODAYCPM     -6.89877E+06  2.45353E+06  -0.6838473  1.00E+00 -2.81178  0.02032

                    Analysis of Variance

Source          Sum-of-Squares   df  Mean-Square    F-ratio      P

Regression        3.75373E+09     1  3.75373E+09   7.9060812   0.0203181
Residual          4.27311E+09     9  4.74790E+08
-------------------------------------------------------------------------------

*** WARNING ***
Case          2 has large leverage   (Leverage =    0.5929831)

Durbin-Watson D Statistic     1.924
First Order Autocorrelation  -0.120
```

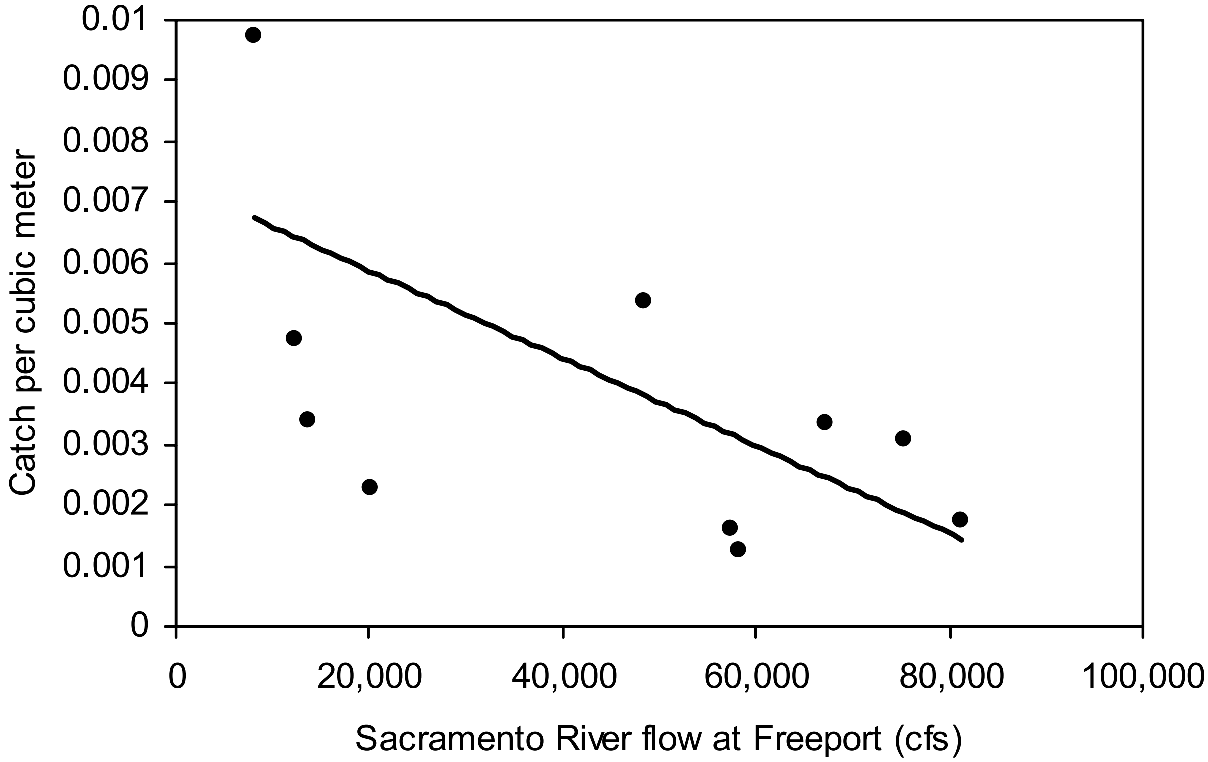


FIGURE 10. Mean catch of chinook smolts between April 1 and June 30 in the midwater trawl at Sacramento regressed with mean February flow at Freeport. **ONE DAY PER WEEK**

>MODEL FLOW = CONSTANT+ONEDAYCPM

Dep Var: FLOW N: 11 Multiple R: 0.6235531 Squared multiple R: 0.3888184

Adjusted squared multiple R: 0.3209094 Standard error of estimate: 2.33473E+04

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.46543E+04	1.20348E+04	0.0	.	5.37227	0.00045
ONEDAYCPM	-5.39230E+06	2.25353E+06	-0.6235531	1.00E+00	-2.39282	0.04037

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	3.12098E+09	1	3.12098E+09	5.7255754	0.0403705
Residual	4.90586E+09	9	5.45095E+08		

*** WARNING ***
Case 2 has large leverage (Leverage = 0.5164592)

Durbin-Watson D Statistic 1.831
First Order Autocorrelation -0.032

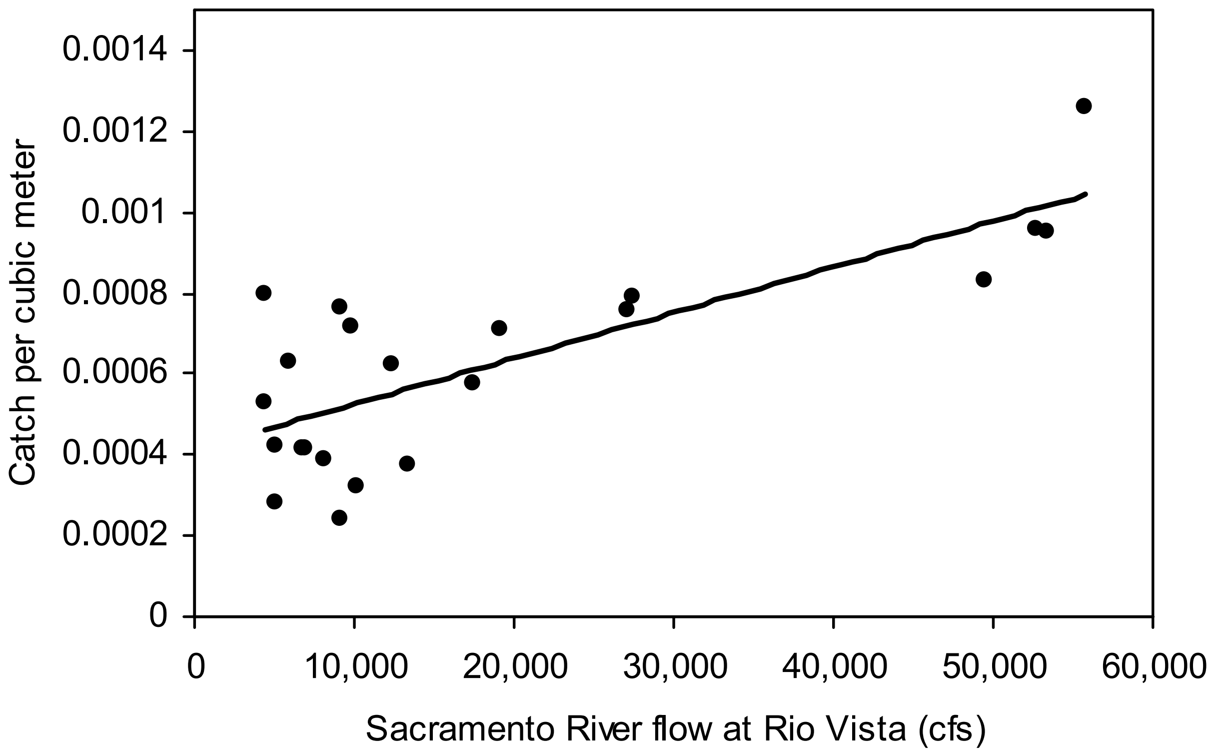


FIGURE 11. Mean catch of chinook smolts between April 1 and June 30 in the midwater trawl at Chipps Island regressed with mean flow at Rio Vista between April 1 and June 30. **FULL EFFORT (THREE TO SEVEN DAYS PER WEEK)**

Dep Var: FLOW N: 22 Multiple R: 0.7218237 Squared multiple R: **0.5210294**

Adjusted squared multiple R: 0.4970809 Standard error of estimate: 1.28526E+04

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	-1.12667E+04	7.35250E+03	0.0	.	-1.53237	0.14110
FULLCPM	5.09372E+07	1.09205E+07	0.7218237	1.00E+00	4.66436	0.00015

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	3.59392E+09	1	3.59392E+09	21.7562162	**0.0001493**
Residual	3.30381E+09	20	1.65190E+08		

Durbin-Watson D Statistic 2.338
First Order Autocorrelation -0.174

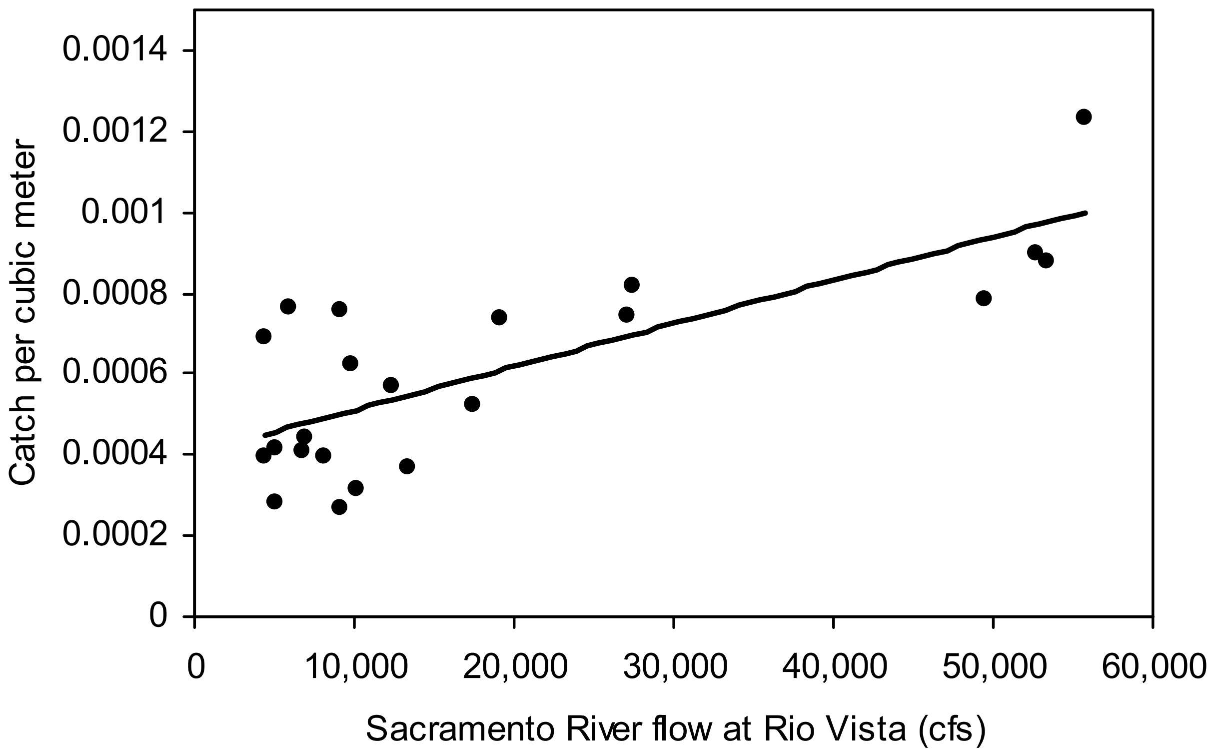


FIGURE 12. Mean catch of chinook smolts between April 1 and June 30 in the midwater trawl at Chipps Island regressed with mean flow at Rio Vista between April 1 and June 30. **TWO DAY PER WEEK EFFORT**

>REGRESS

>MODEL FIRSTANDLAST = CONSTANT+FLOW

>ESTIMATE

Dep Var: FIRSTANDLAST N: 22 Multiple R: 0.6616644 Squared multiple R: **0.4377997**

Adjusted squared multiple R: 0.4096897 Standard error of estimate: 0.0001898

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.0004192	0.0000620	0.0	.	6.75977	0.00000
FLOW	0.0000000	0.0000000	0.6616644	1.00E+00	3.94646	0.00080

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.0000006	1	0.0000006	15.5745105	**0.0007973**
Residual	0.0000007	20	0.0000000		

Durbin-Watson D Statistic 2.614
First Order Autocorrelation -0.324

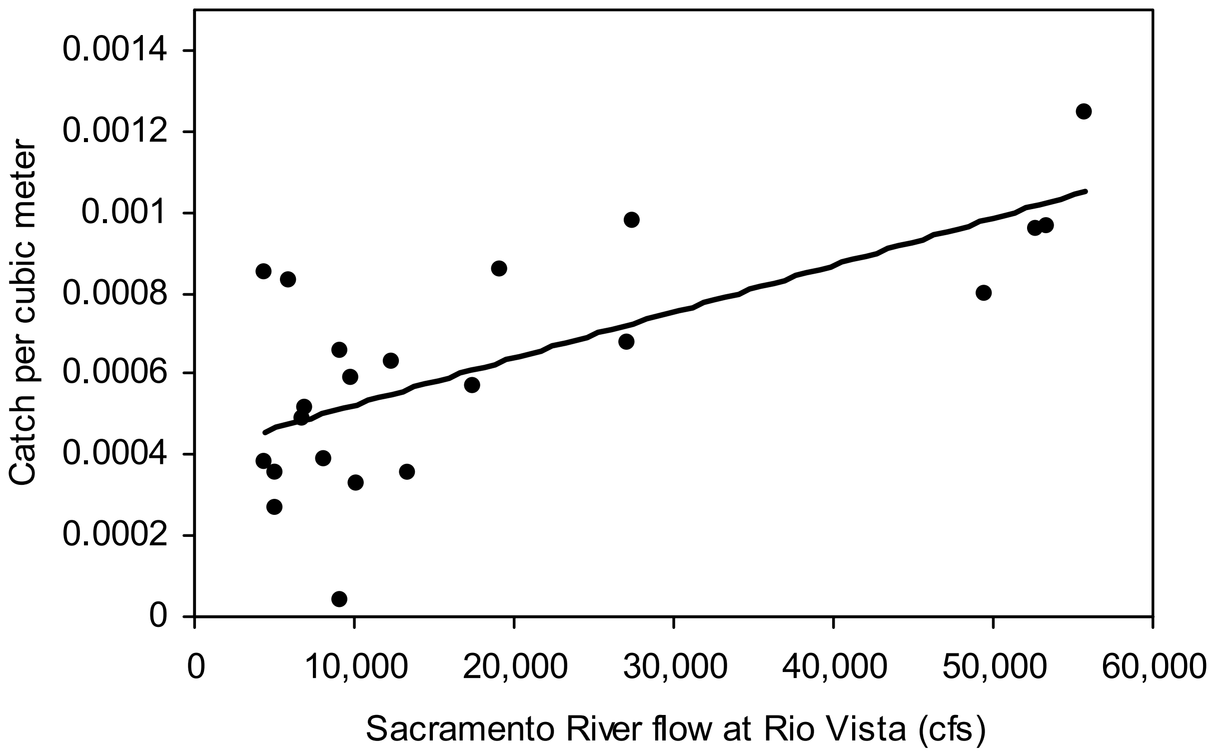


FIGURE 13. Mean catch of chinook smolts between April 1 and June 30 in the midwater trawl at Chipps Island regressed with mean flow at Rio Vista between April 1 and June 30. **ONE DAY PER WEEK EFFORT**

>MODEL FIRSTDAY = CONSTANT+FLOW

>ESTIMATE

Dep Var: FIRSTDAY N: 22 Multiple R: 0.6038586 Squared multiple R: **0.3646452**

Adjusted squared multiple R: 0.3328774 Standard error of estimate: 0.0002366

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.0004257	0.0000773	0.0	.	5.50812	0.00002
FLOW	0.0000000	0.0000000	0.6038586	1.00E+00	3.38799	0.00292

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.0000006	1	0.0000006	11.4784738	**0.0029211**
Residual	0.0000011	20	0.0000001		

Durbin-Watson D Statistic 2.708
First Order Autocorrelation -0.382

FIGURE 14.
NUMBER CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC AREA BEACH SEINE, OCT 1993 - MAR 1994

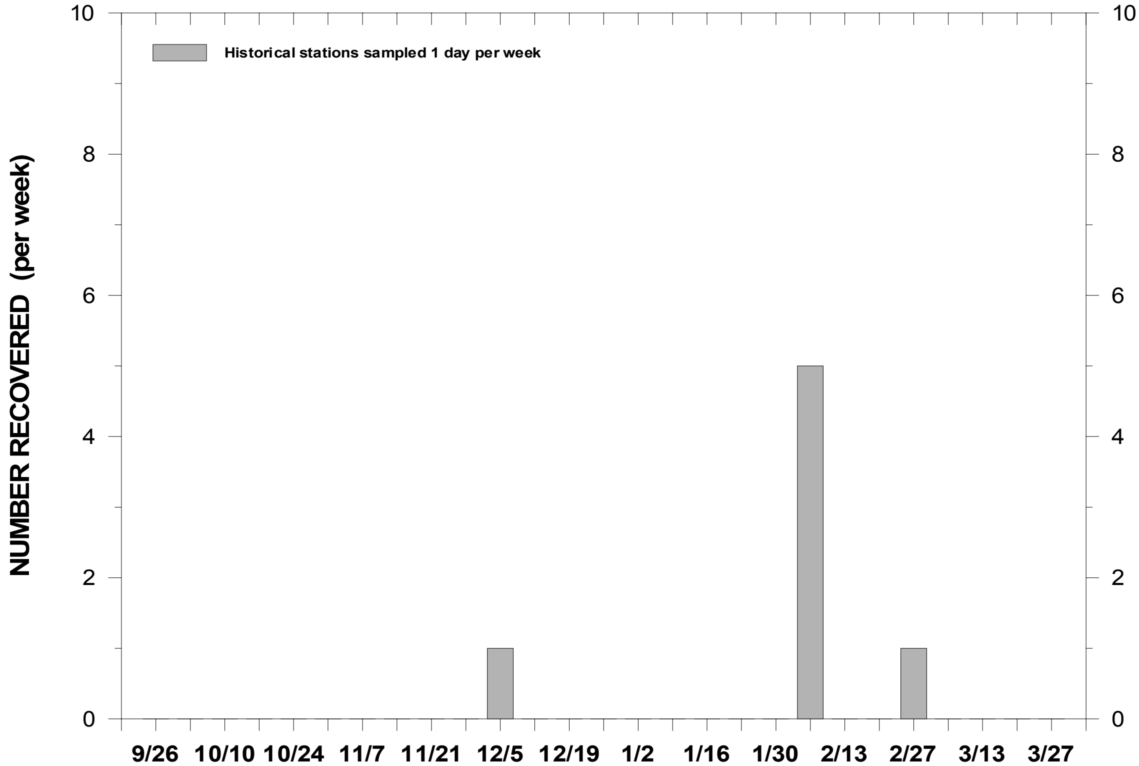
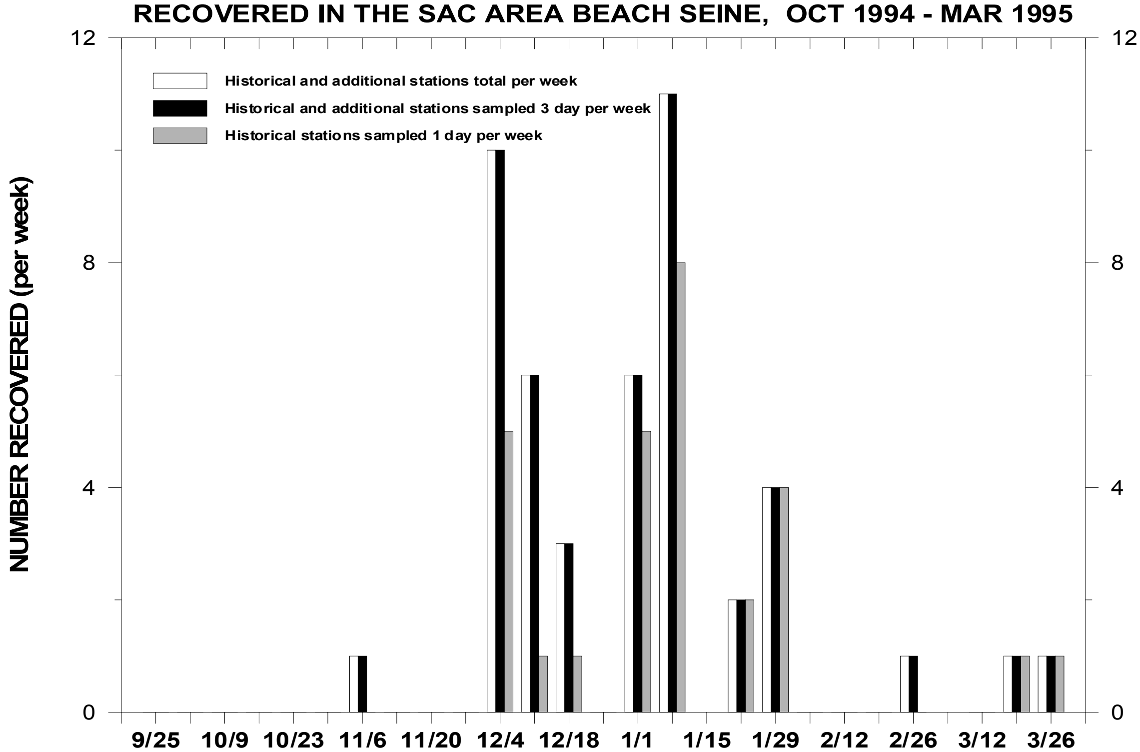


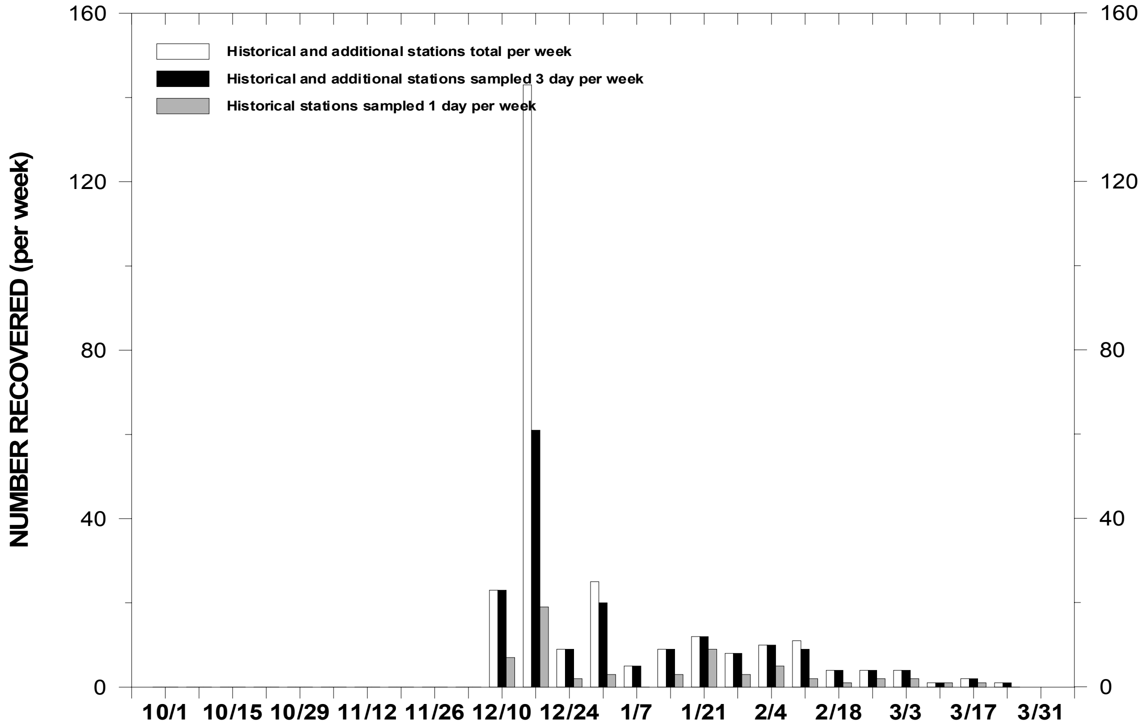
FIGURE 15.
NUMBER CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC AREA BEACH SEINE, OCT 1994 - MAR 1995



Note: For weeks 17 and 24 sampling was < 3 days per weeks so data not included.

FIGURE 16.

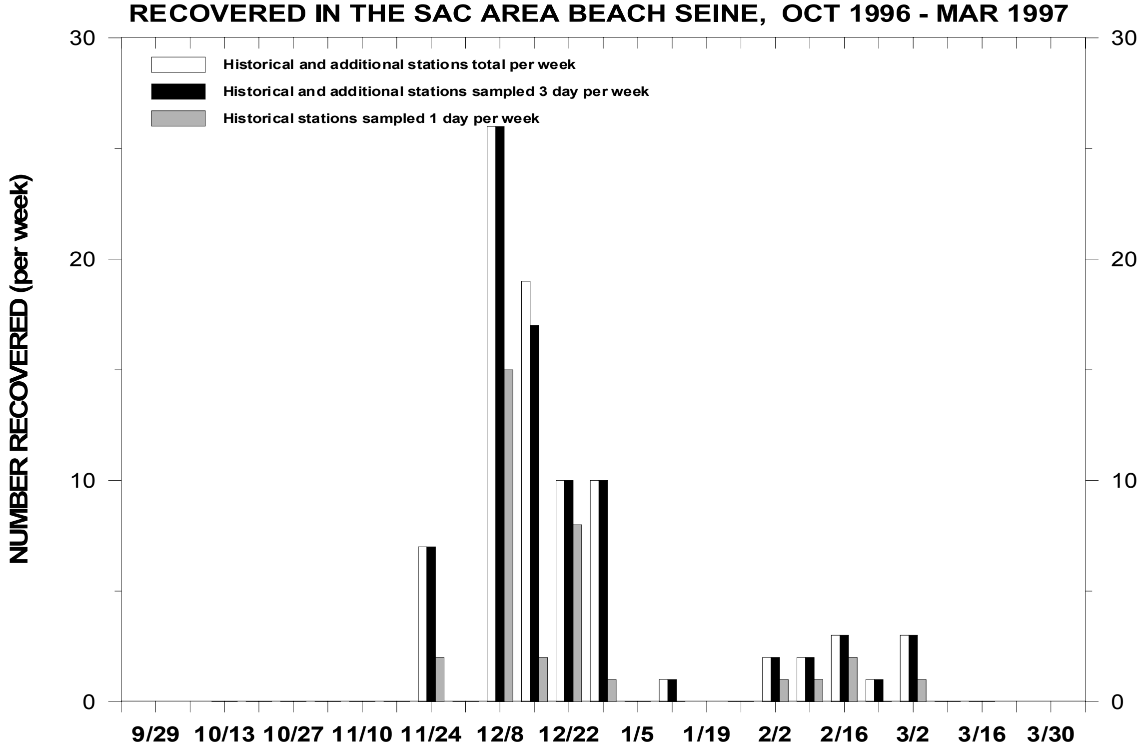
NUMBER CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC AREA BEACH SEINE, OCT 1995 - MAR 1996



Note: For week 27 sampling < 3 days per week so data not included.

FIGURE 17.

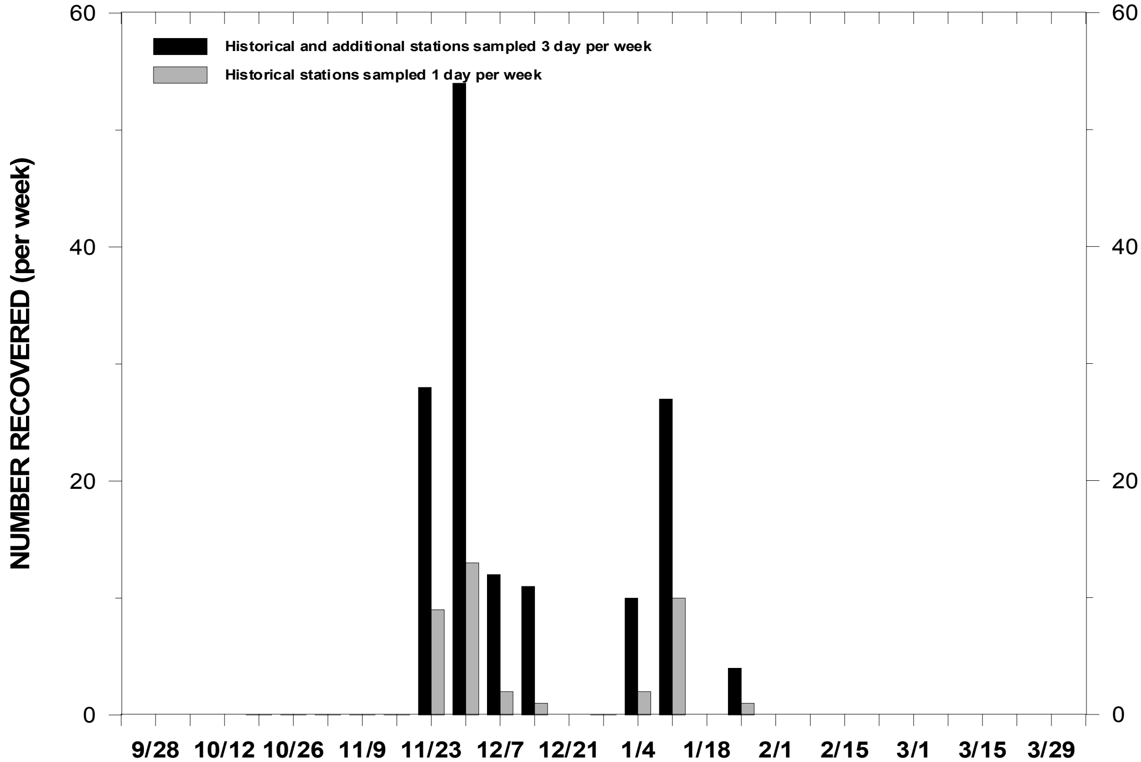
NUMBER CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC AREA BEACH SEINE, OCT 1996 - MAR 1997



Note: For weeks 1, 2, 17, 26, and 27 sampling was < 3 days per week so data not included.

FIGURE 18.

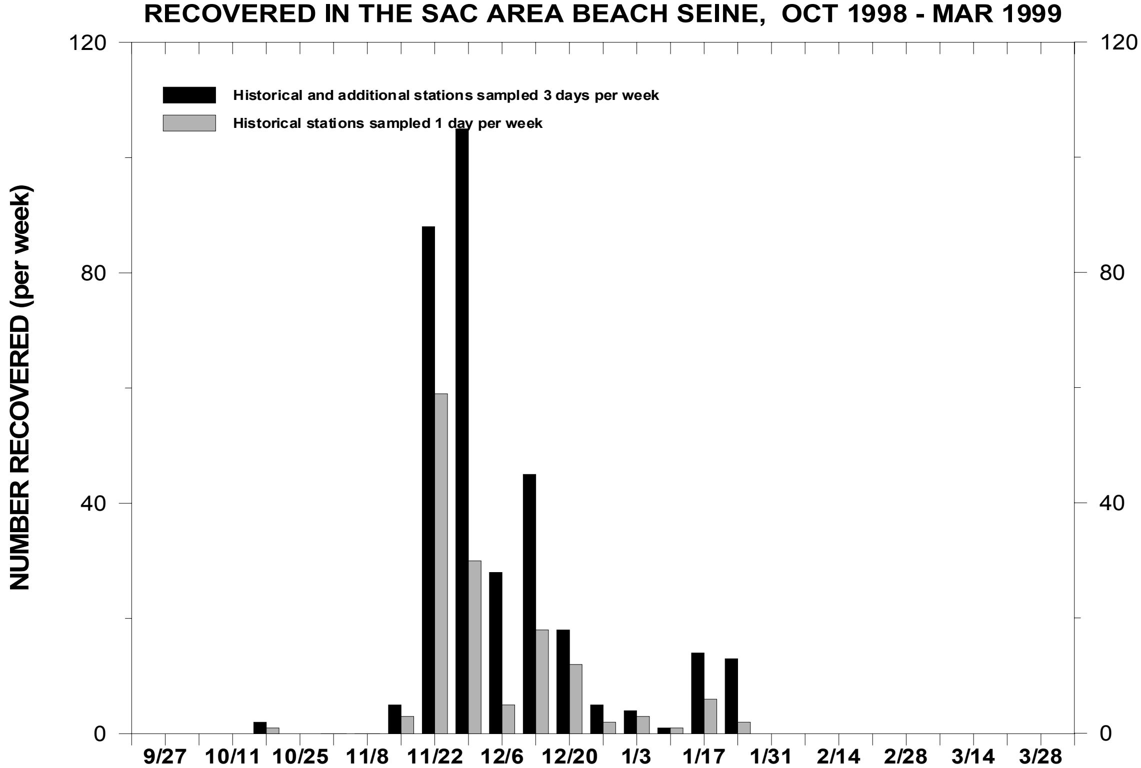
NUMBER CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC AREA BEACH SEINE, OCT 1997 - MAR 1998



Note: For weeks 1-3, 13, 17, and 19-27 sampling was < 3 days per week so data not included.

FIGURE 19.

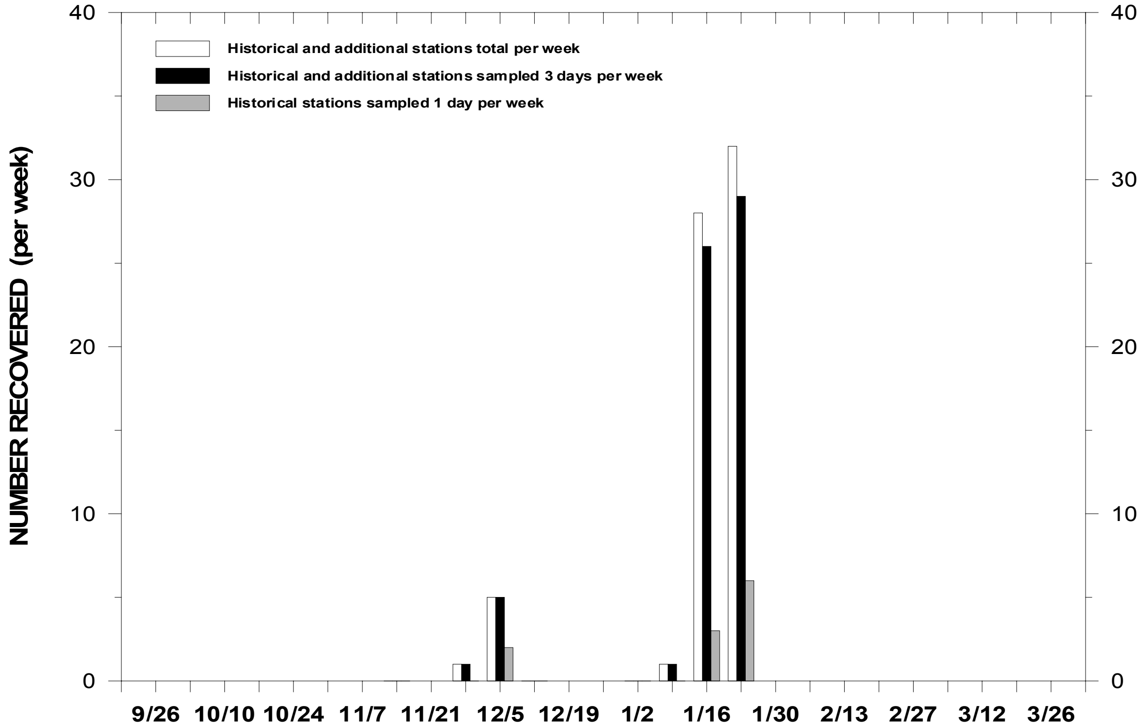
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC AREA BEACH SEINE, OCT 1998 - MAR 1999



Note: For weeks 1, 2, 3, 5 and 19-27 sampling was < 3 days per week so data not included

FIGURE 20.

NUMBER CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC AREA BEACH SEINE, OCT 1999 - MAR 2000



Note: For weeks 1-7, 9, 13-14, and 19-27 sampling was < 3 days per week so data not included

TABLE 20

TIMING OF CHINOOK, ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SACRAMENTO AREA BEACH SEINE, OCTOBER THROUGH MARCH

	VERONA	ELKHORN SLOUGH	SAND COVE	DISCOVERY PARK	MILLER PARK	SHERWOOD HARBOR	GARCIA BEND
1994							
TOTAL RECOVERED	1	5	*	0	*	*	1
FIRST RECOVERY	2/9/94	12/8/93	*	-	*	*	2/28/94
LAST RECOVERY	2/9/94	2/9/94	*	-	*	*	2/28/94
AVG. RECOVERY	2/9/94	1/27/94	*	-	*	*	2/28/94
1995							
TOTAL RECOVERED	11	16	2	2	5	5	9
FIRST RECOVERY	1/8/95	12/7/94	12/11/94	1/6/95	12/7/94	11/9/94	12/7/94
LAST RECOVERY	3/29/95	2/3/95	12/12/94	3/20/95	2/27/95	1/6/95	2/1/95
AVG. RECOVERY	1/18/95	12/27/94	12/11/94	2/11/95	12/30/94	12/10/94	1/10/95
1996							
TOTAL RECOVERED	20	113	13	21	67	0	37
FIRST RECOVERY	12/13/95	12/14/95	12/28/95	12/14/95	12/15/95	-	12/15/95
LAST RECOVERY	3/6/96	3/21/96	1/12/96	3/11/96	3/27/96	-	3/4/96
AVG. RECOVERY	1/17/96	12/25/95	1/4/96	12/31/95	1/8/96	-	1/7/96
1997							
TOTAL RECOVERED	25	19	4	3	24	5	4
FIRST RECOVERY	12/11/96	12/9/96	12/30/96	11/26/96	12/11/96	11/25/96	11/26/96
LAST RECOVERY	3/3/97	2/14/97	3/5/97	12/27/96	3/5/97	11/26/96	2/19/97
AVG. RECOVERY	12/21/96	12/28/96	2/12/97	12/11/96	12/25/96	11/26/96	1/1/97
1998							
TOTAL RECOVERED	27	67	13	14	27	5	26
FIRST RECOVERY	11/26/97	11/28/97	11/26/97	11/28/97	12/1/97	11/26/97	12/1/97
LAST RECOVERY	1/16/98	1/30/98	1/20/98	1/14/98	1/30/98	12/10/97	1/7/98
AVG. RECOVERY	12/18/97	12/18/97	12/7/97	12/5/97	1/7/98	12/1/97	12/6/97
1999							
TOTAL RECOVERED	35	187	9	55	37	2	36
FIRST RECOVERY	11/23/98	11/20/98	11/16/98	9/30/98	11/25/98	10/23/98	11/20/98
LAST RECOVERY	2/11/99	2/2/99	1/25/99	2/2/99	12/31/98	11/23/98	3/2/99
AVG. RECOVERY	12/19/98	12/11/98	12/24/98	12/2/98	12/5/98	11/7/98	12/6/98
2000**							
TOTAL RECOVERED	3	28	10	2	10	3	19
FIRST RECOVERY	1/23/00	11/5/99	1/16/00	1/28/00	1/15/00	12/3/99	12/6/99
LAST RECOVERY	2/1/00	1/28/00	2/3/00	2/1/00	1/28/00	1/19/00	2/10/00
AVG. RECOVERY	1/29/00	1/19/00	1/23/00	1/30/00	1/22/00	1/3/00	1/12/00

* Station not sampled

** Data preliminary, subject to revision

Table 21

NUMBER OF CHINOOK, ABOVE THE MINIMUM WINTER RUN LENGTH LINE, RECOVERED IN THE SAC RIVER KODIAK TRAWL, OCTOBER THROUGH JANUARY

FIELD SEASON	NUMBER OF CHINOOK RECOVERED: SAMPLING 3 DAYS A WEEK	NUMBER OF CHINOOK RECOVERED: SAMPLING 3 OR MORE DAYS A WEEK	DIFFERENCE	% INCREASED
1995	7	7	0	0
1996	101	119	18	15
1997	20	26	6	23
1998	37	42	5	12
1999	103	103	0	0
1995-1999	**268**	**297**	**29**	**10**

TABLE 22.

TOTAL NUMBER OF CHINOOK RECOVERED, OCTOBER THROUGH JANUARY

FIELD SEASON	STATION	GROUP 1* NUMBER RECOVERED	GROUP 1* EXPANDED NUMBER	GROUP 2** NUMBER RECOVERED	GROUP 2** EXPANDED NUMBER
1995/1996	KNIGHTS L.	249	349	11,027	14,503
	SAC. RIVER	118	169	5,678	9,089
1996/1997	KNIGHTS L.	225	273	12,761	14,926
	SAC. RIVER	27	46	339	1,264
1997/1998	KNIGHTS L.	669	964	11,711	14,015
	SAC. RIVER	45	144	2,184	2,792
1998/1999	KNIGHTS L.	647	924	7,023	8,200
	SAC. RIVER	110	229	1,736	3,762

*Group 1 included all chinook above the minimum winter run length line, based on the Fisher Model.
**Group 2 included all chinook below the minimum winter run length line, based on the Fisher Model.

TABLE 23.

COLEMAN HATCHERY LATE FALL & SHASTA REARING FACILITY WINTER RUN RECOVERED, OCTOBER - JANUARY

DATE RELEASED	TAGCODE	RACE	DATE OF FIRST RECOVERY	
			SAC. RIVER TRAWL	KNIGHTS LANDING SCREW TRAP
11/10/97	05-50-40	Late Fall	11/25/97	12/1/97
11/10/97	05-50-41	Late Fall	11/18/97	12/21/97
12/9/97	05-50-42	Late Fall	12/16/97	12/15/97
12/9/97	05-50-48	Late Fall	12/15/97	12/14/97
1/13/98	05-50-51	Late Fall	1/20/98	1/19/98
1/13/98	05-50-52	Late Fall	1/21/98	1/20/98
1/13/98	05-50-53	Late Fall	1/23/98	1/23/98
1/14/98	05-50-54	Late Fall	1/28/98	1/22/98
1/14/98	05-50-55	Late Fall	1/23/98	1/17/98
1/14/98	05-50-56	Late Fall	1/23/98	1/19/98
1/12/98	05-50-59	Late Fall	1/26/98	1/19/98
1/22/98	05-50-57	Late Fall	1/26/98	1/25/98
1/22/98	05-50-58	Late Fall	1/28/98	1/25/98
4/9/98	05-01-01-15-12	Winter	4/20/98	4/18/98
11/12/98	5/23/09	Late Fall	11/27/98	12/3/98
11/12/98	5/23/11	Late Fall	11/23/98	11/22/98
12/15/98	5/23/16	Late Fall	1/11/99	12/19/98
12/15/98	5/23/17	Late Fall	12/21/98	12/19/98
1/4/99	5/23/18	Late Fall	1/19/99	1/14/99
1/4/99	5/23/19	Late Fall	1/19/99	1/11/99
1/4/99	05-41-28	Late Fall	1/14/99	1/12/99
1/4/99	05-41-29	Late Fall	1/12/99	1/10/99
1/28/99	05-01-02-08-11	Winter	*	2/7/99
1/28/99	05-01-02-08-12	Winter	3/22/99	2/4/99
1/28/99	05-01-02-08-13	Winter	3/22/99	2/2/99
1/28/99	05-01-02-08-14	Winter	*	2/7/99
1/28/99	05-01-02-08-15	Winter	*	2/5/99
1/28/99	05-01-02-09-01	Winter	*	2/5/99
1/28/99	05-01-02-09-02	Winter	2/8/99	2/2/99
1/28/99	05-01-02-09-03	Winter	*	2/6/99
1/28/99	05-01-02-09-05	Winter	*	2/6/99
1/28/99	05-01-02-09-06	Winter	*	2/7/99
1/28/99	05-01-02-09-07	Winter	2/11/99	2/5/99
1/28/99	05-01-02-09-08	Winter	*	2/2/99
1/28/99	05-01-02-09-09	Winter	*	2/2/99
1/28/99	05-01-02-09-10	Winter	*	2/3/99
1/28/99	05-01-02-09-11	Winter	*	2/4/99
1/28/99	05-01-02-09-12	Winter	2/18/99	3/28/99
1/28/99	05-01-02-09-13	Winter	*	2/3/99
1/28/99	05-01-02-09-14	Winter	*	2/3/99
1/28/99	05-01-02-09-15	Winter	*	2/6/99

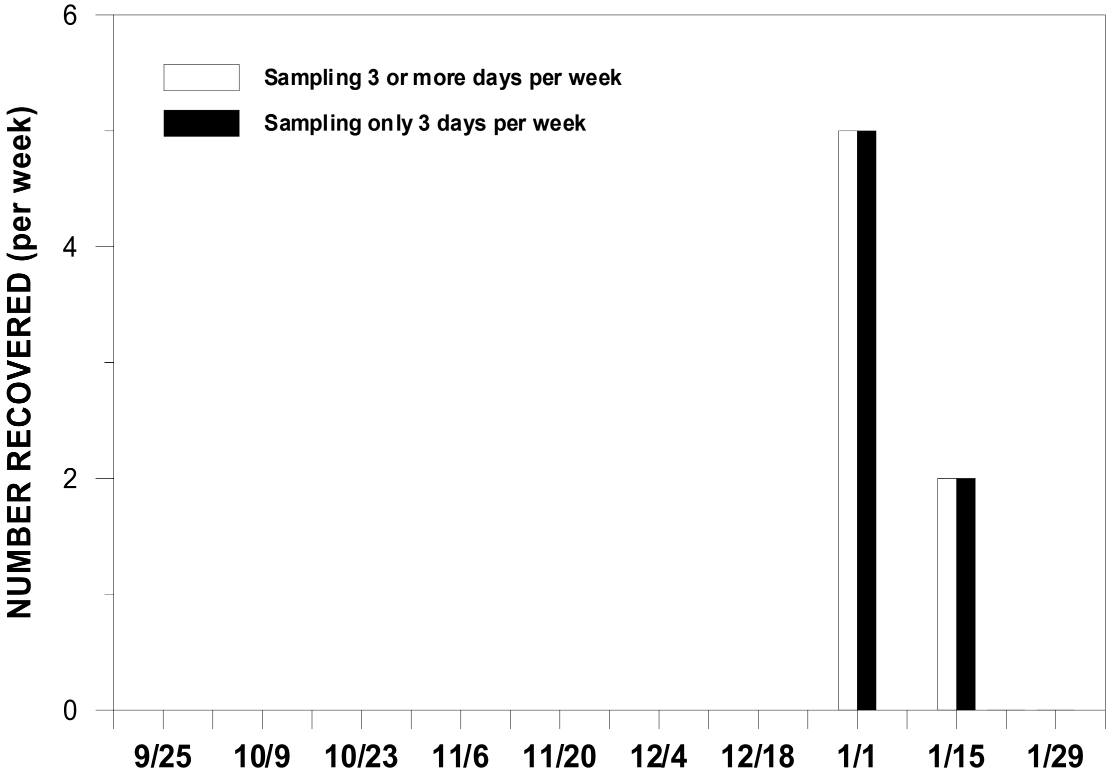
TABLE 24.

MINIMUM, MAXIMUM, AND AVERAGE MONTHLY FORK LENGTHS FOR CHINOOK RECOVERED BETWEEN OCTOBER AND JANUARY

		GROUP 1			GROUP 2		
STATION	**DATE**	**MINIMUM**	**MAXIMUM**	**AVERAGE**	**MINIMUM**	**MAXIMUM**	**AVERAGE**
KNIGHTS L.	Oct-95	*	*	*	*	*	*
SAC. RIVER	Oct-95	*	*	*	*	*	*
KNIGHTS L.	Nov-95	*	*	*	*	*	*
SAC. RIVER	Nov-95	*	*	*	*	*	*
KNIGHTS L.	Dec-95	35	144	78	29	47	36
SAC. RIVER	Dec-95	51	140	87	25	48	34
KNIGHTS L.	Jan-96	56	198	104	23	63	37
SAC. RIVER	Jan-96	59	142	104	30	59	37
KNIGHTS L.	**Oct - Jan**	**35**	**198**	**91**	**23**	**63**	**37**
SAC. RIVER	**Oct - Jan**	**51**	**142**	**93**	**25**	**59**	**36**
KNIGHTS L.	Oct-96	*	*	*	*	*	*
SAC. RIVER	Oct-96	*	*	*	*	*	*
KNIGHTS L.	Nov-96	61	141	84	30	38	34
SAC. RIVER	Nov-96	62	142	114	36	36	36
KNIGHTS L.	Dec-96	61	145	90	28	44	36
SAC. RIVER	Dec-96	52	137	95	30	40	36
KNIGHTS L.	Jan-97	60	170	105	28	59	36
SAC. RIVER	Jan-97	165	165	165	33	48	38
KNIGHTS L.	**Oct - Jan**	**60**	**170**	**92**	**28**	**59**	**36**
SAC. RIVER	**Oct - Jan**	**52**	**165**	**105**	**30**	**48**	**37**
KNIGHTS L.	Oct-97	38	38	38	*	*	*
SAC. RIVER	Oct-97	75	89	82	*	*	*
KNIGHTS L.	Nov-97	45	134	71	28	39	35
SAC. RIVER	Nov-97	51	127	92	33	34	33.5
KNIGHTS L.	Dec-97	49	155	74	29	42	35
SAC. RIVER	Dec-97	63	123	90	29	38	35
KNIGHTS L.	Jan-98	61	130	84	29	58	37
SAC. RIVER	Jan-98	69	89	79	30	55	37
KNIGHTS L.	**Oct - Jan**	**38**	**155**	**73**	**28**	**58**	**36**
SAC. RIVER	**Oct - Jan**	**51**	**127**	**90**	**29**	**55**	**37**
KNIGHTS L.	Oct-98	37	37	37	*	*	*
SAC. RIVER	Oct-98	49	108	73	*	*	*
KNIGHTS L.	Nov-98	38	135	69	33	41	37
SAC. RIVER	Nov-98	52	131	77	33	33	33
KNIGHTS L.	Dec-98	51	136	71	29	52	35
SAC. RIVER	Dec-98	52	133	86	34	39	37
KNIGHTS L.	Jan-99	65	132	89	27	62	37
SAC. RIVER	Jan-99	72	110	95	20	55	37
KNIGHTS L.	**Oct - Jan**	**37**	**136**	**72**	**27**	**62**	**37**
SAC. RIVER	**Oct - Jan**	**49**	**133**	**81**	**20**	**55**	**37**

FIGURE 21.

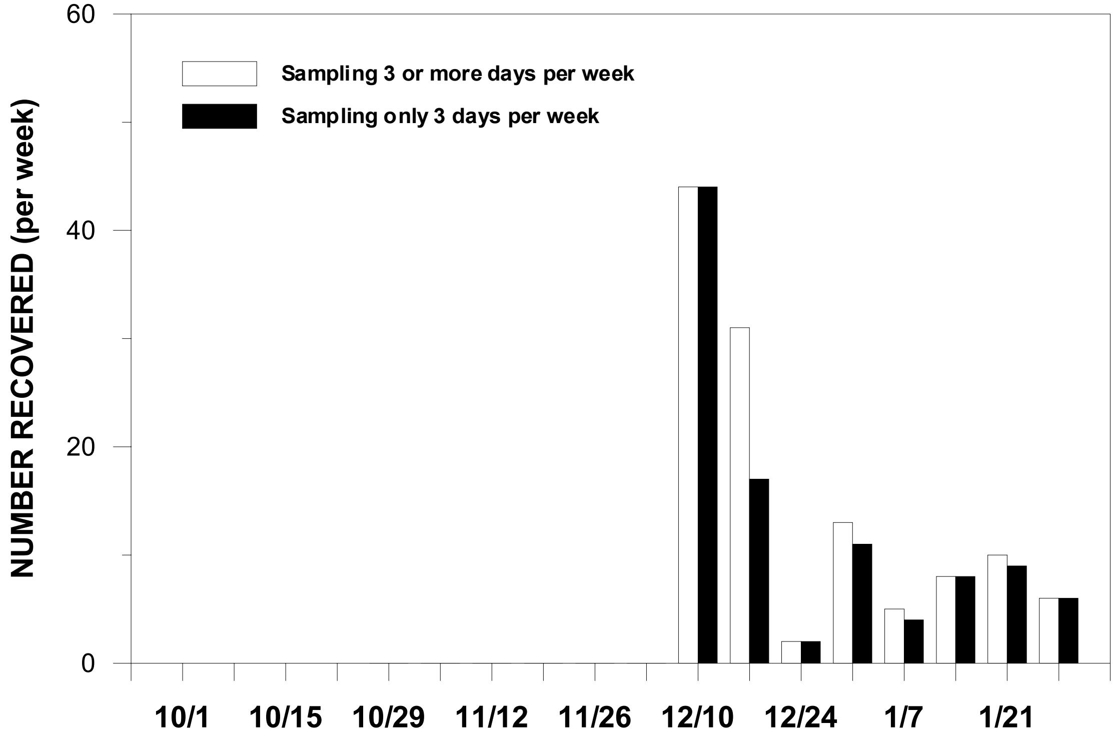
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK TRAWL, OCT 1994 - JAN 1995



Note: For weeks 1-14 and 16 sampling < 3 days per week.

FIGURE 22.

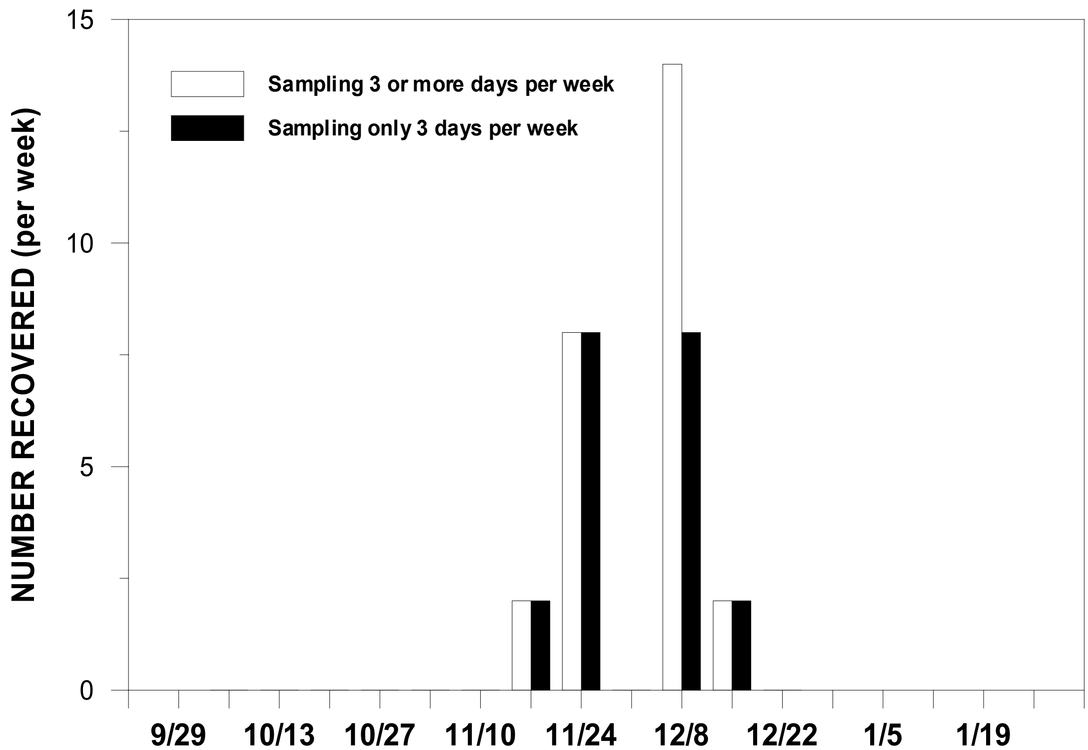
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC RIVER KODIAK TRAWL, OCT 1995 - JAN 1996



Note: For weeks 1-4 sampling < 3 days per week.

FIGURE 23.

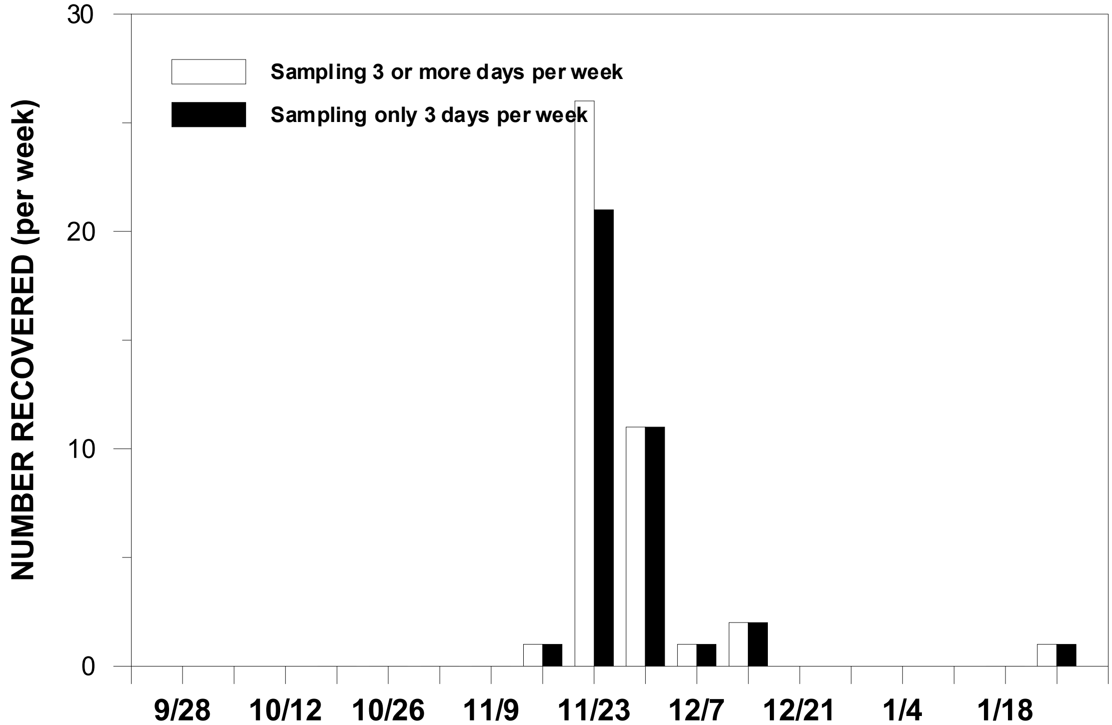
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC RIVER KODIAK TRAWL, OCT 1996 - JAN 1997



Note: For weeks 1, 14-18 sampling < 3 days per week

FIGURE 24.

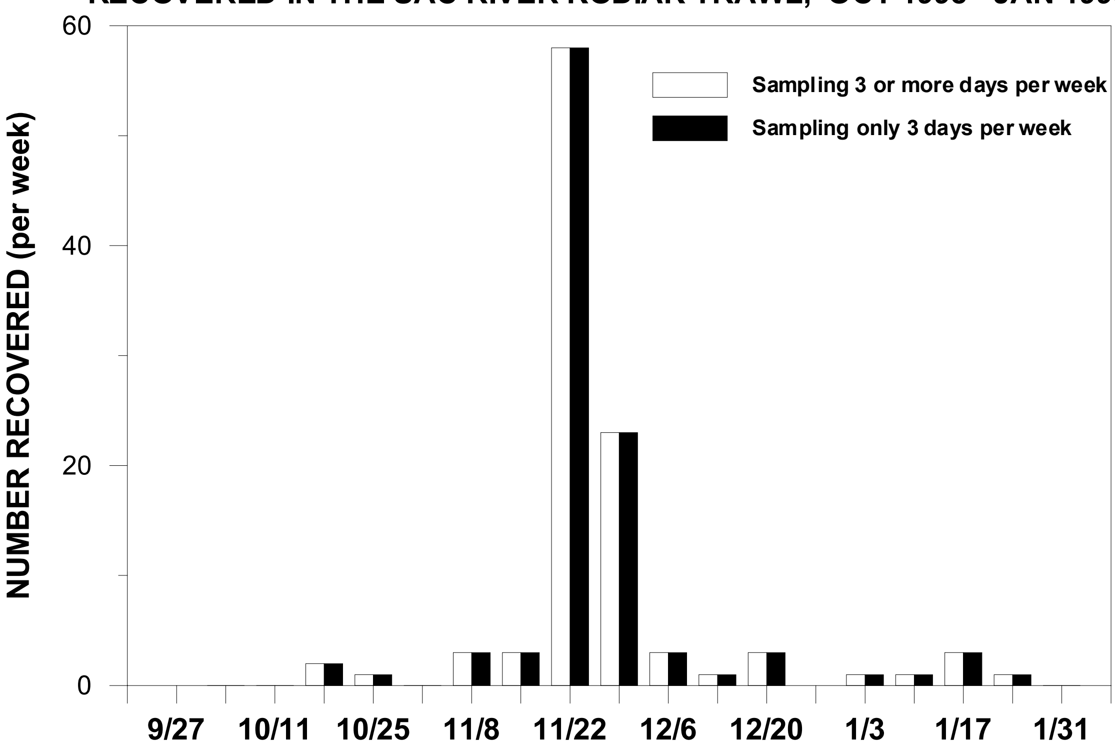
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC RIVER KODIAK TRAWL, OCT 1997 - JAN 1998



Note: For weeks 1-3, 13-16 sampling < 3 days per week.

FIGURE 25.

NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC RIVER KODIAK TRAWL, OCT 1998 - JAN 1999



Note: For weeks 1 and 14 sampling < 3 days per week

Figure 26.

NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED AT KNIGHTS LANDING OCTOBER 1995 - JANUARY 1996

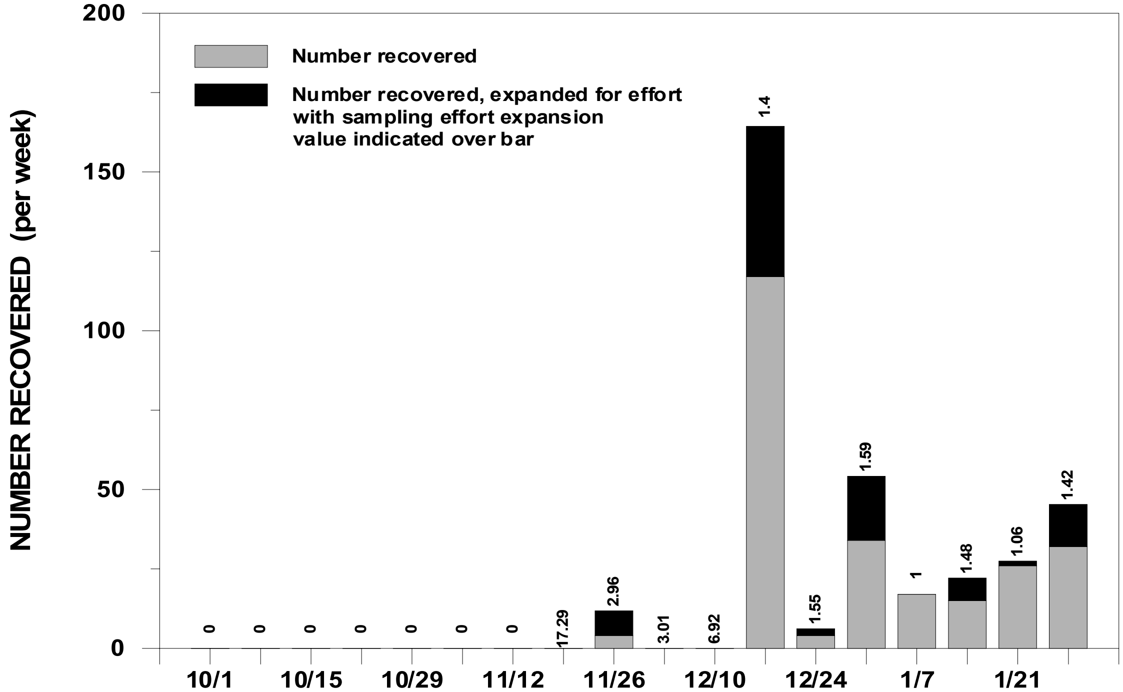


FIGURE 27.

NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER TRAWL, OCTOBER 1995 - JANUARY 1996

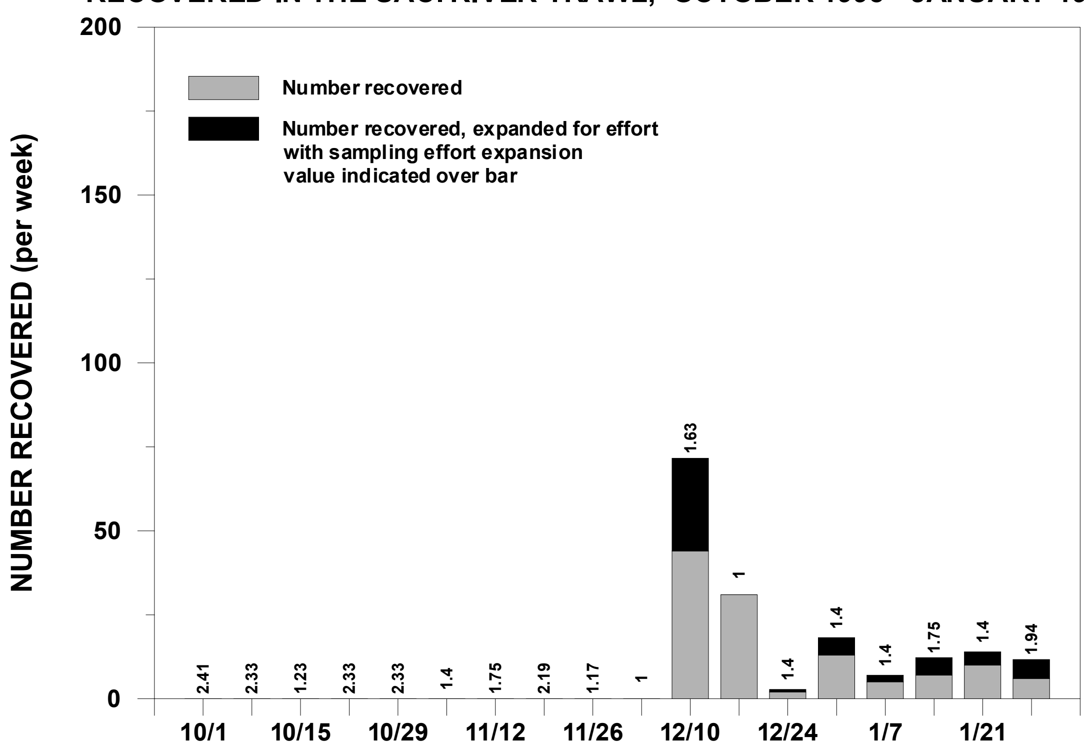


FIGURE 28.
NUMBER OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED AT KNIGHTS LANDING, OCTOBER 1995 - JANUARY 1996

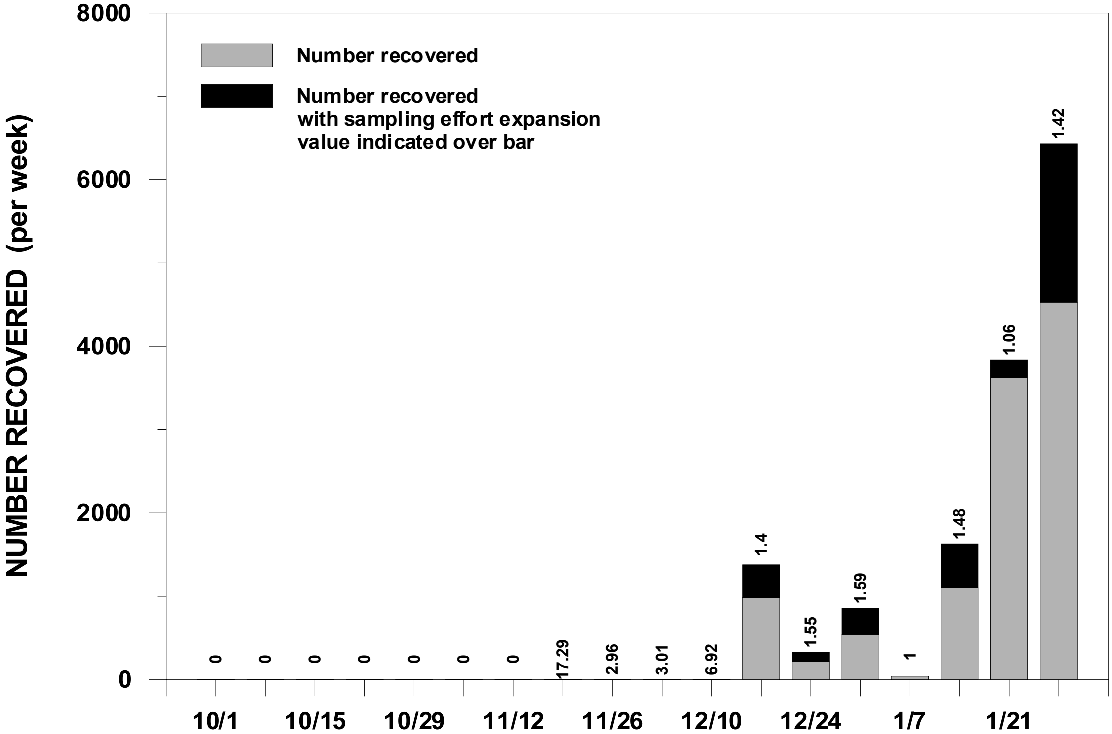


FIGURE 29.
NUMBER OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER TRAWL, OCTOBER 1995 - JANUARY 1996

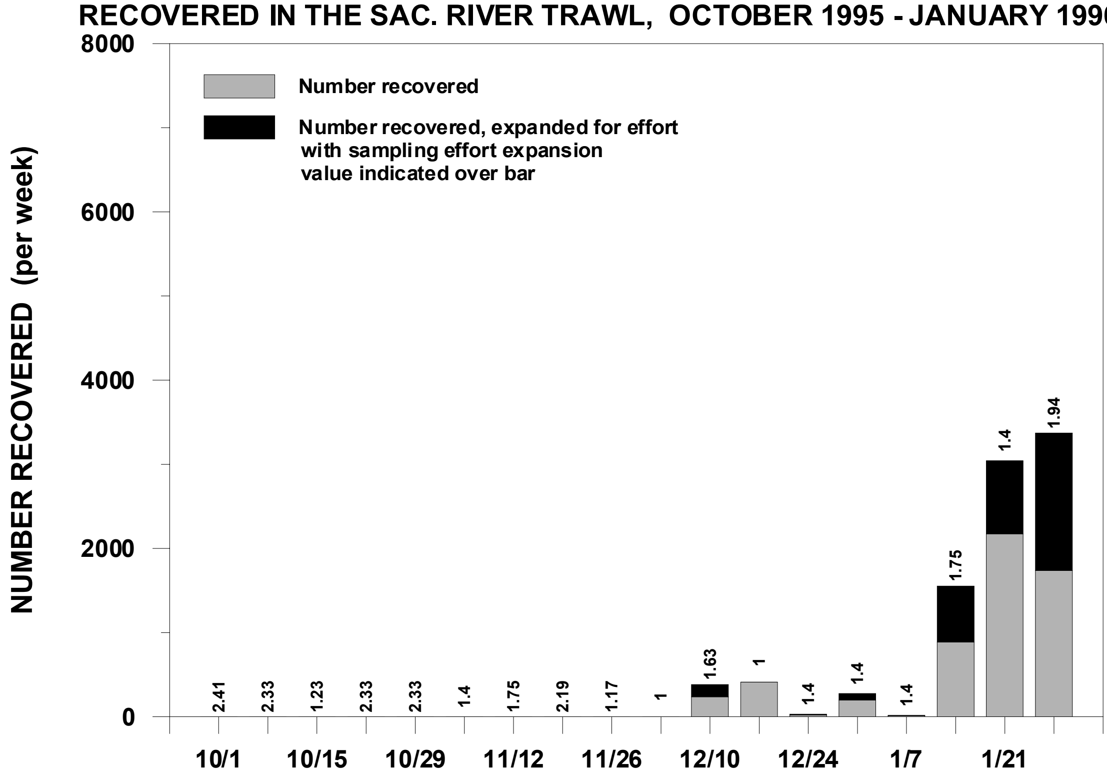


FIGURE 30.
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED AT KNIGHTS LANDING, OCTOBER 1996 - JANUARY 1997

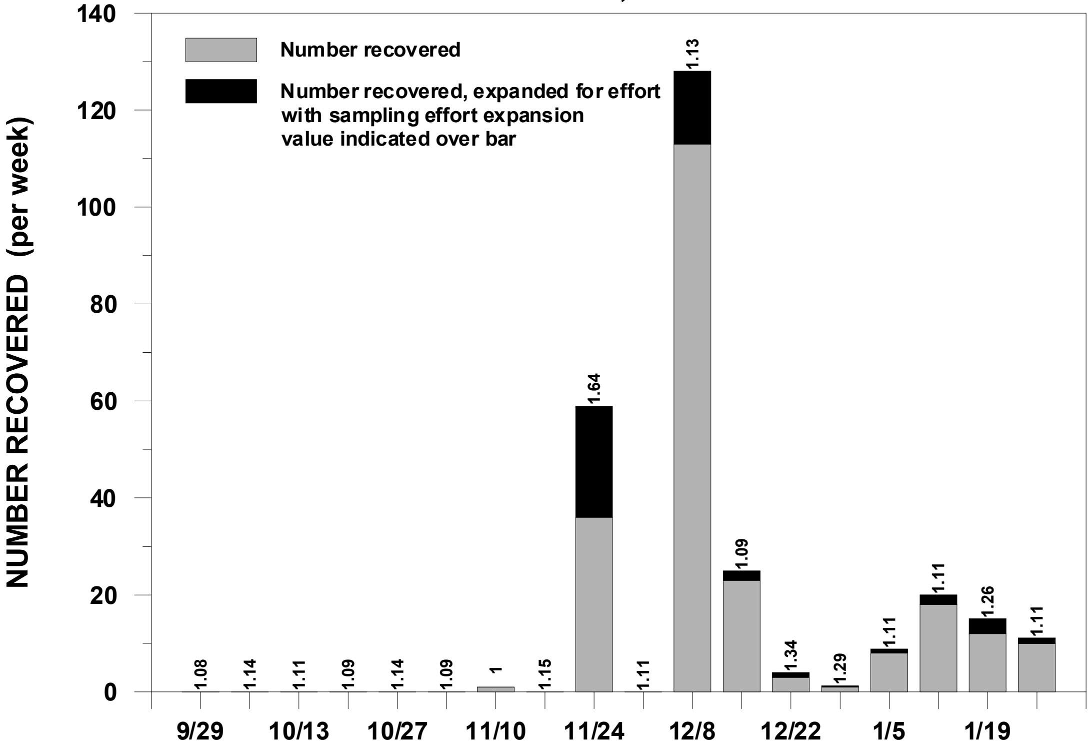


FIGURE 31.
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER TRAWL, OCTOBER 1996 - JANUARY 1997

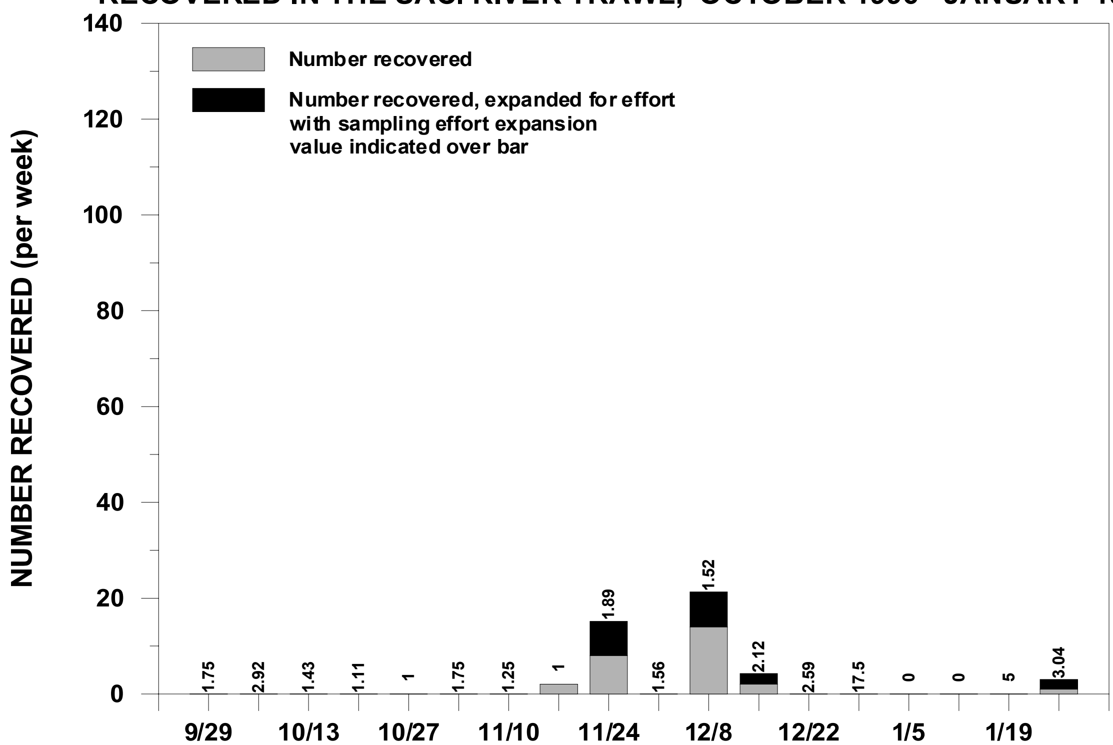


FIGURE 32.
NUMBER OF CHINOOK BELBOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED AT KNIGHTS LANDING, OCTOBER 1996 - JANUARY 1997

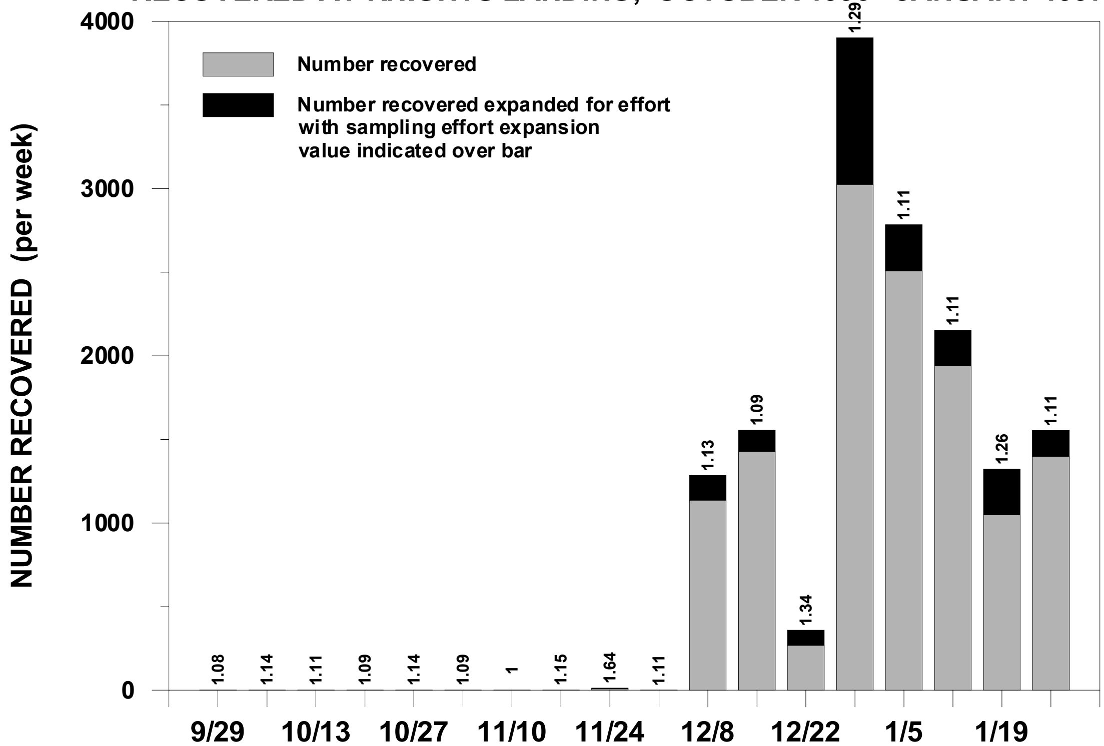


FIGURE 33.
NUMBER OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER TRAWL, OCTOBER 1996 - JANUARY 1997

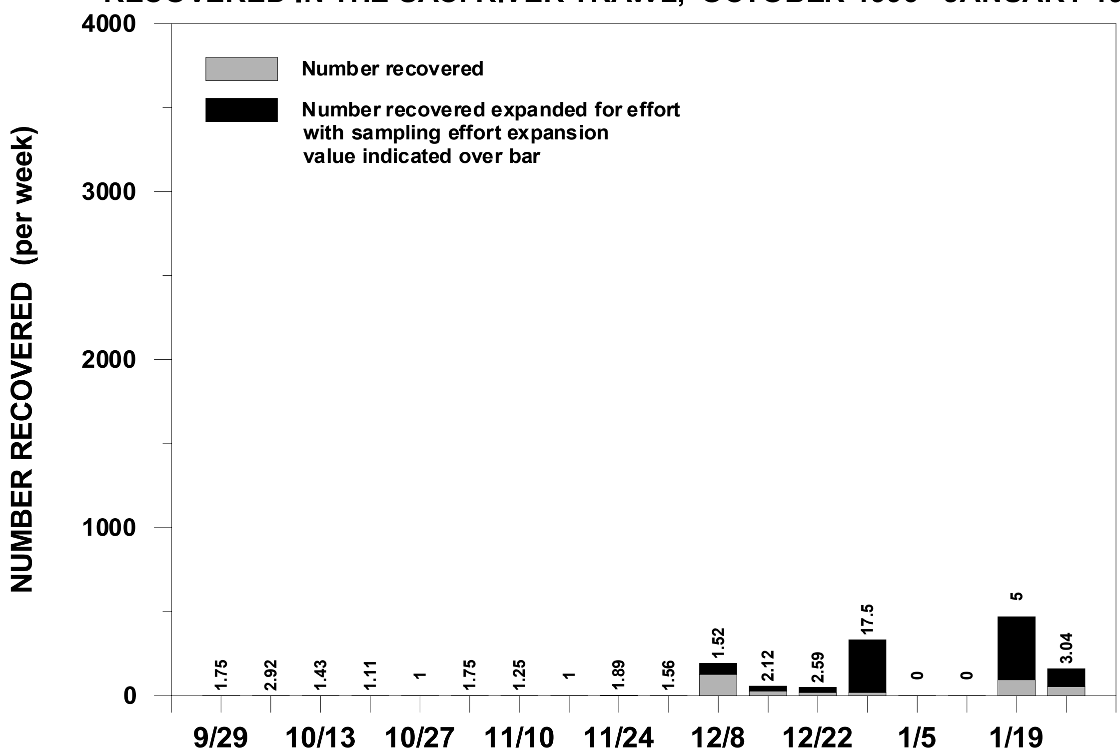


FIGURE 34.
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED AT KNIGHTS LANDING, OCTOBER 1997 - JANUARY 1998

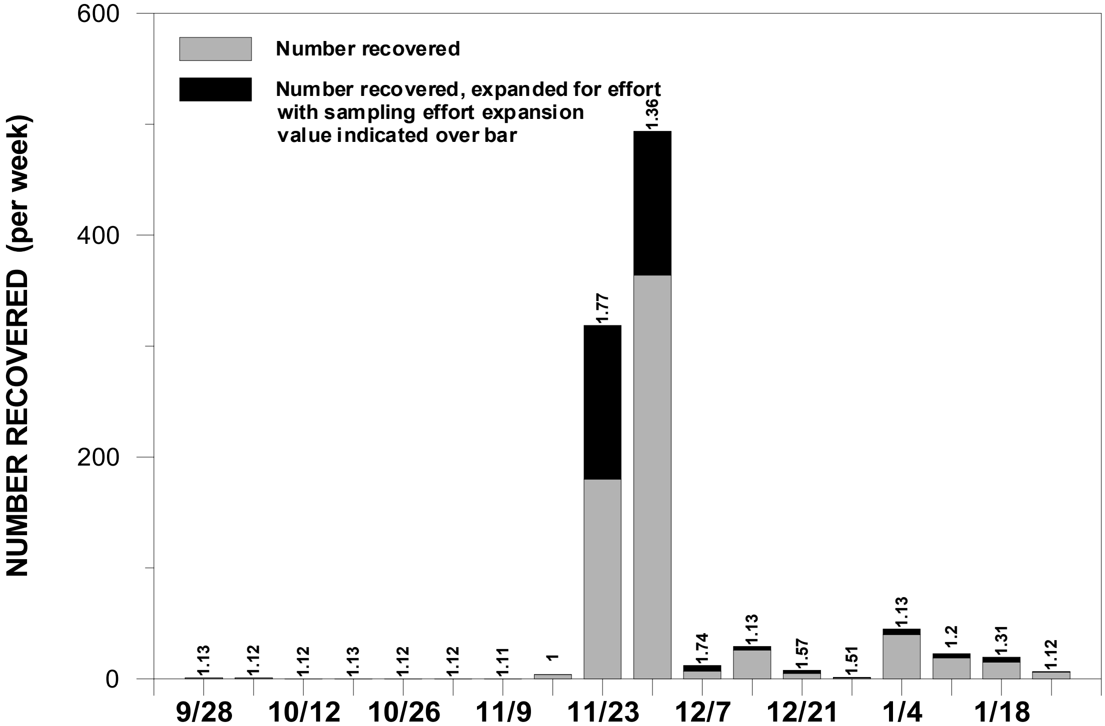


FIGURE 35.
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER TRAWL, OCTOBER 1997 - JANUARY 1998

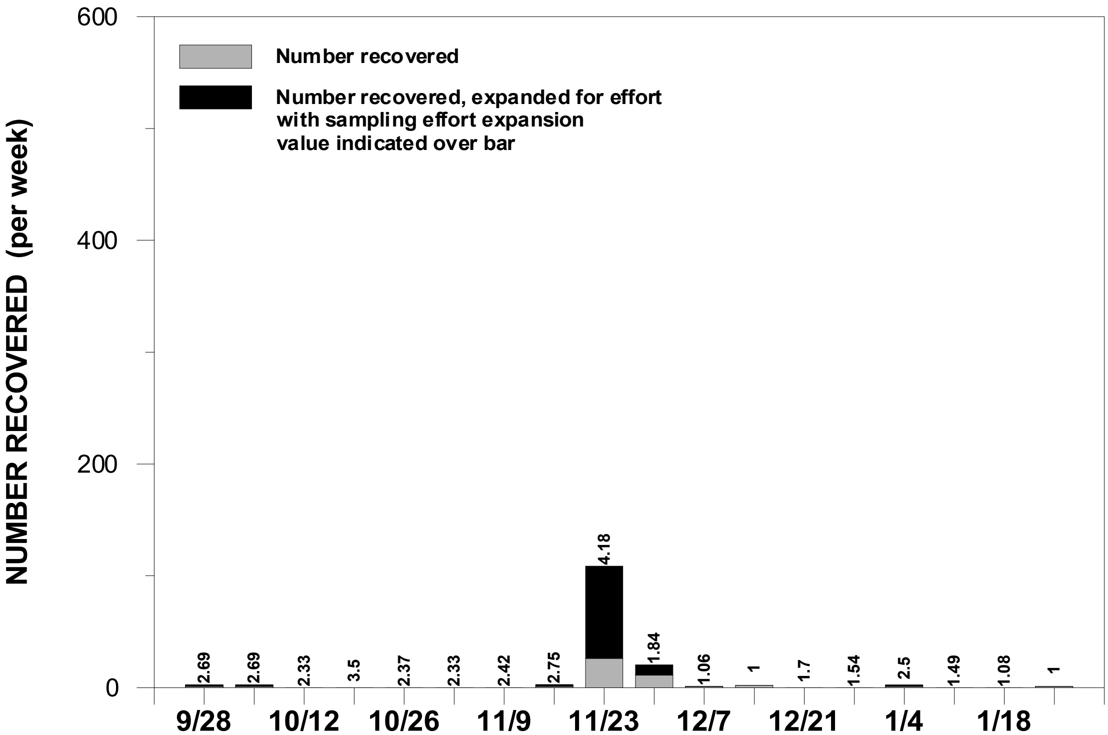


FIGURE 36.
NUMBER OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE
RECOVERED AT KNIGHTS LANDING, OCTOBER 1997 - JANUARY 1998

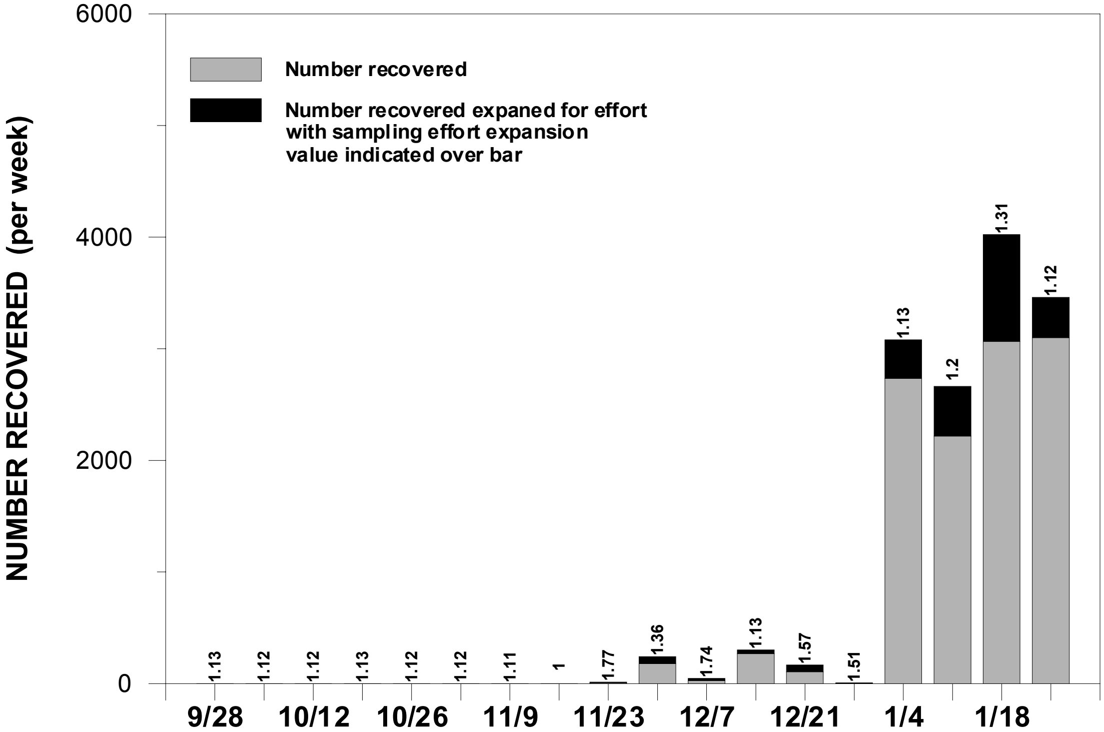


FIGURE 37.
NUMBER OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE
RECOVERED IN THE SAC. RIVER TRAWL, OCTOBER 1997 - JANUARY 1998

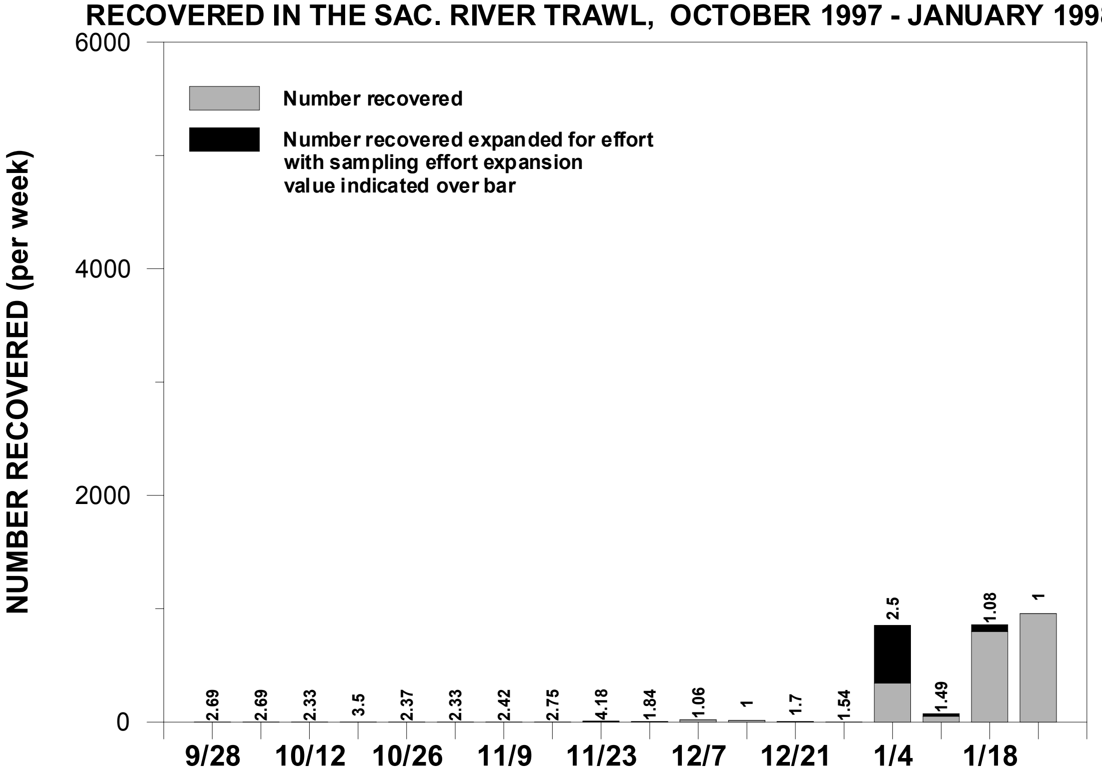


FIGURE 38.
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED AT KNIGHTS LANDING, OCTOBER 1998 - JANUARY 1999

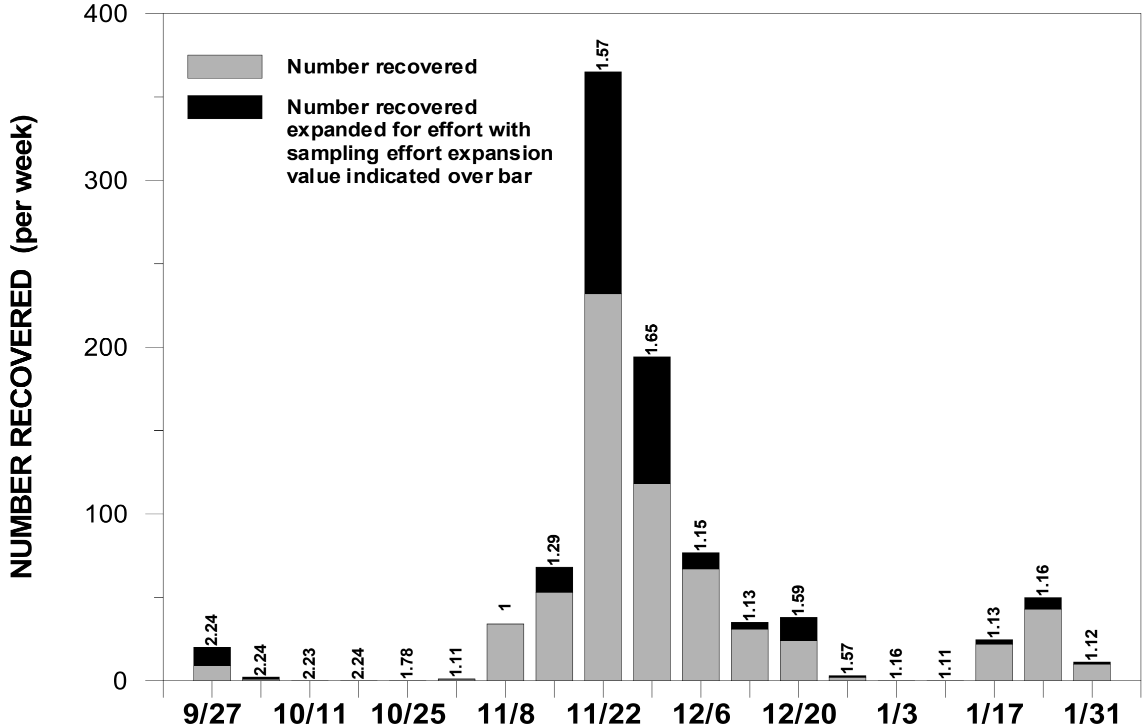


FIGURE 39.
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER TRAWL, OCTOBER 1998 - JANUARY 1999

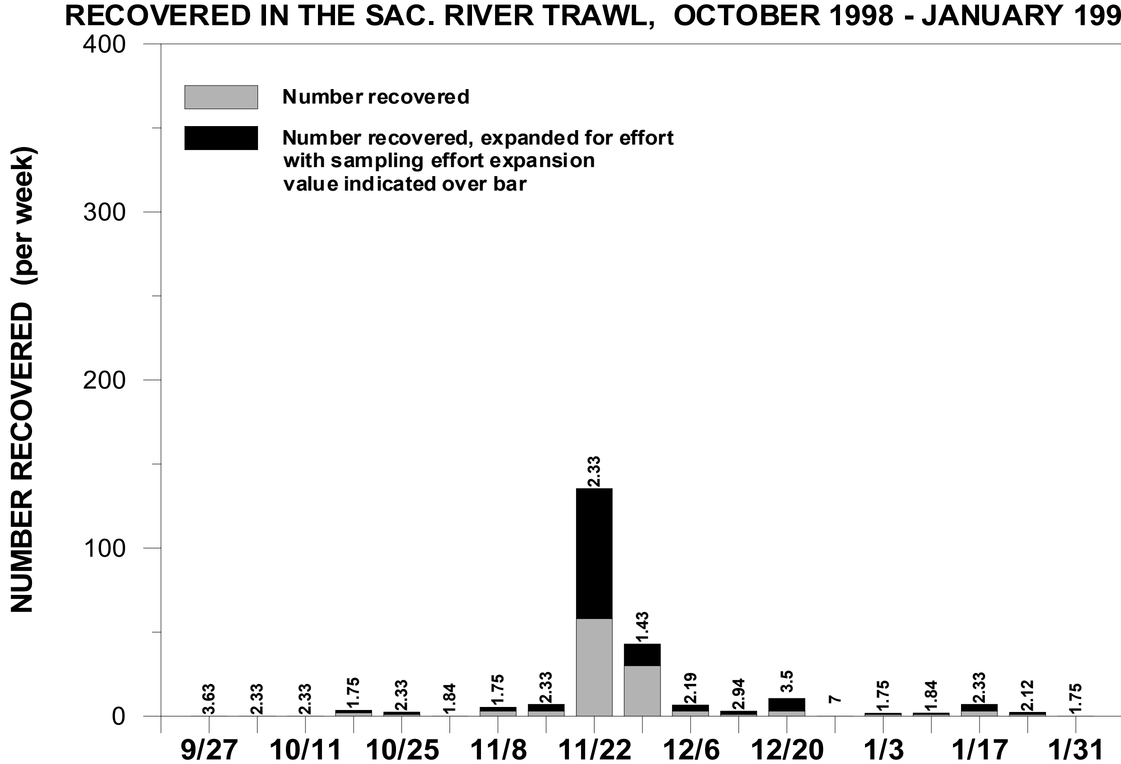


FIGURE 40.
NUMBER OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED AT KNIGHTS LANDING, OCTOBER 1998 - JANUARY 1999

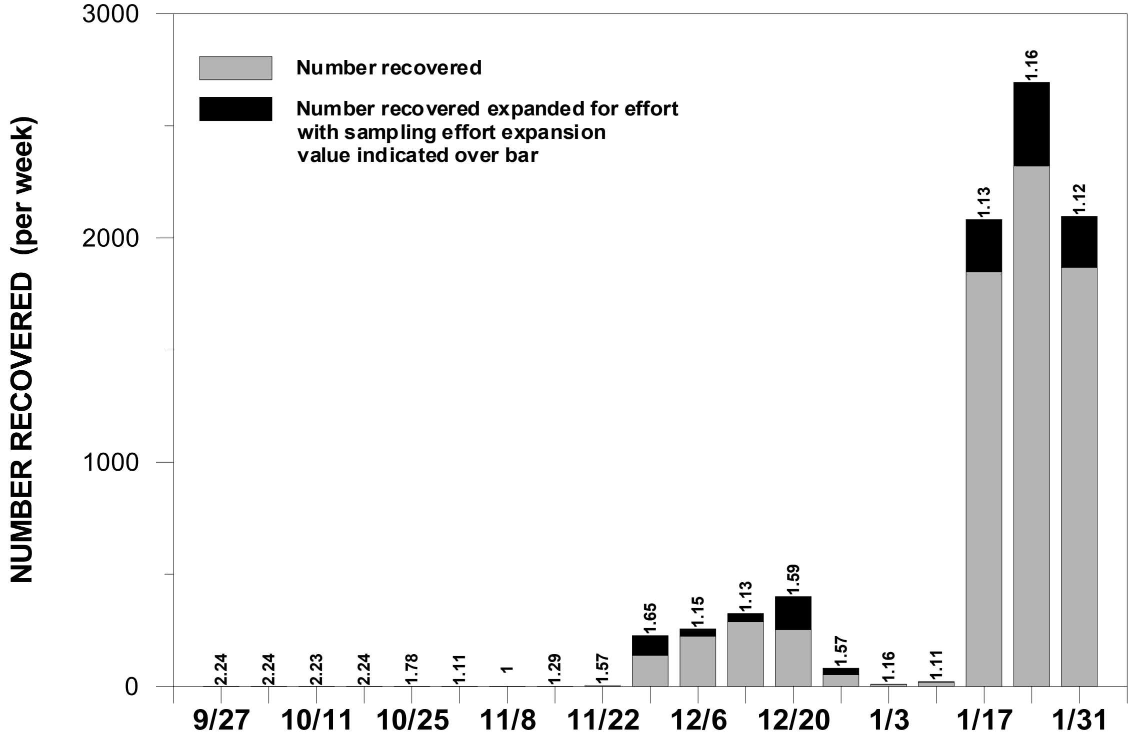


FIGURE 41.
NUMBER OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER TRAWL, OCTOBER 1998 - JANUARY 1999

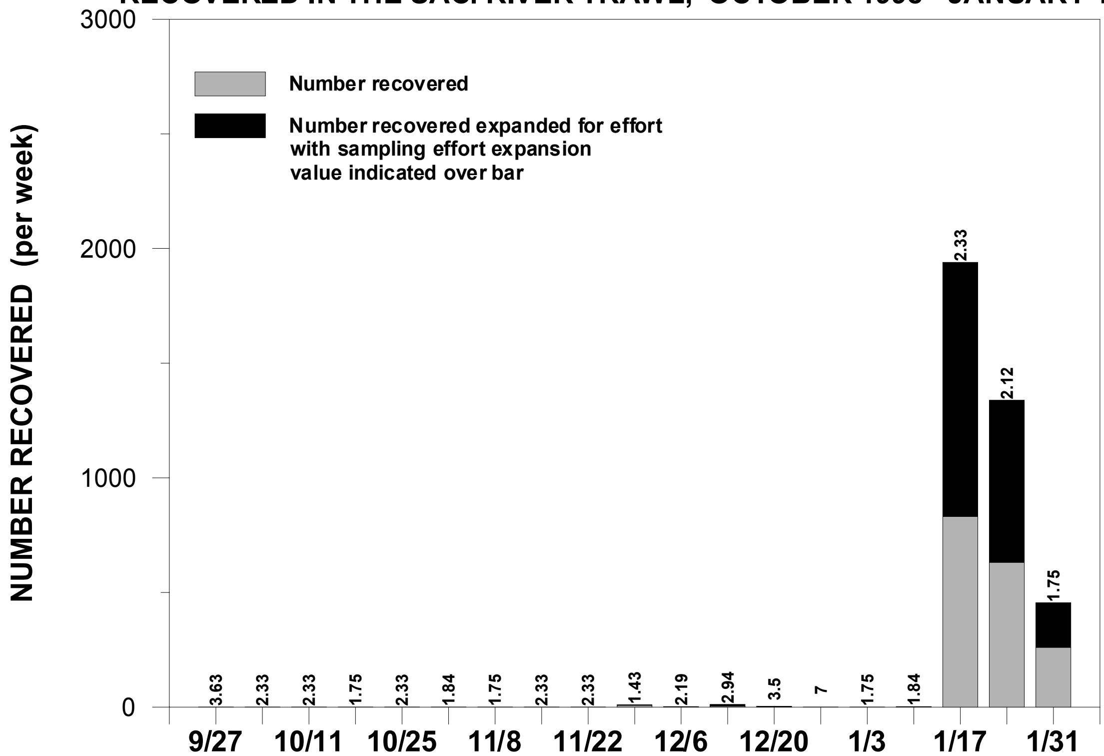
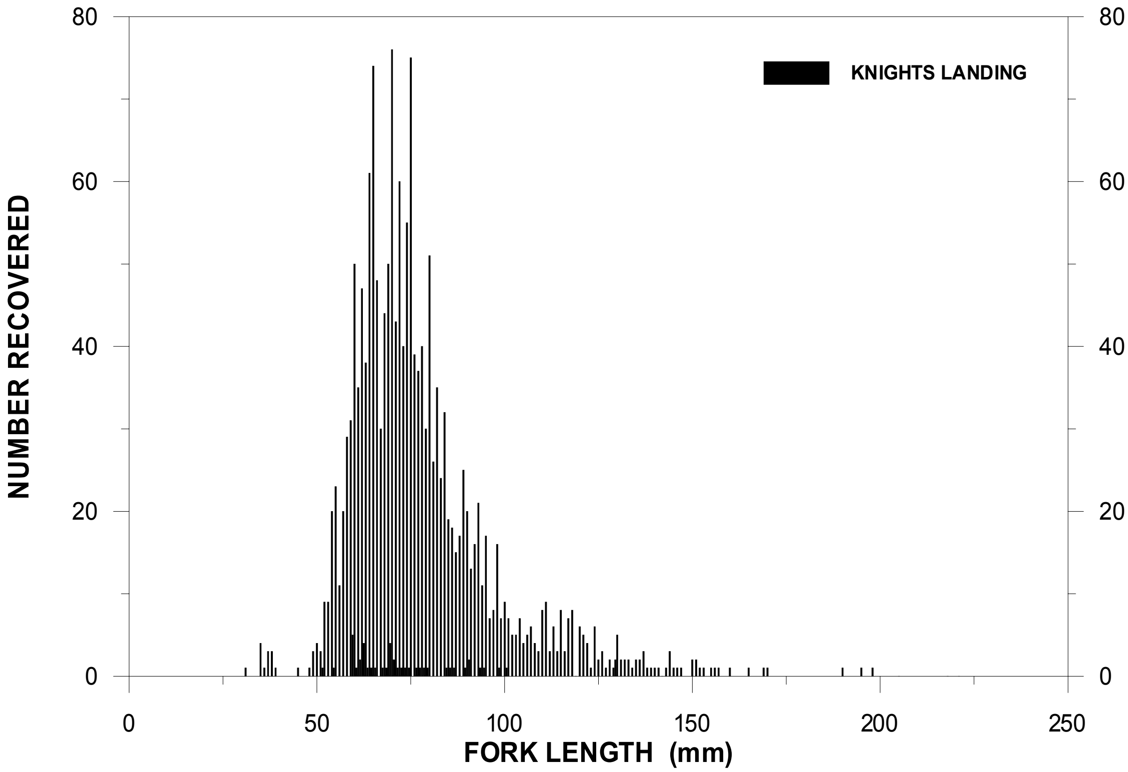


FIGURE 42.
NUMBER OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED VERSUS LENGTH, BETWEEN OCT AND JAN FOR WATER YEARS 1995-1999



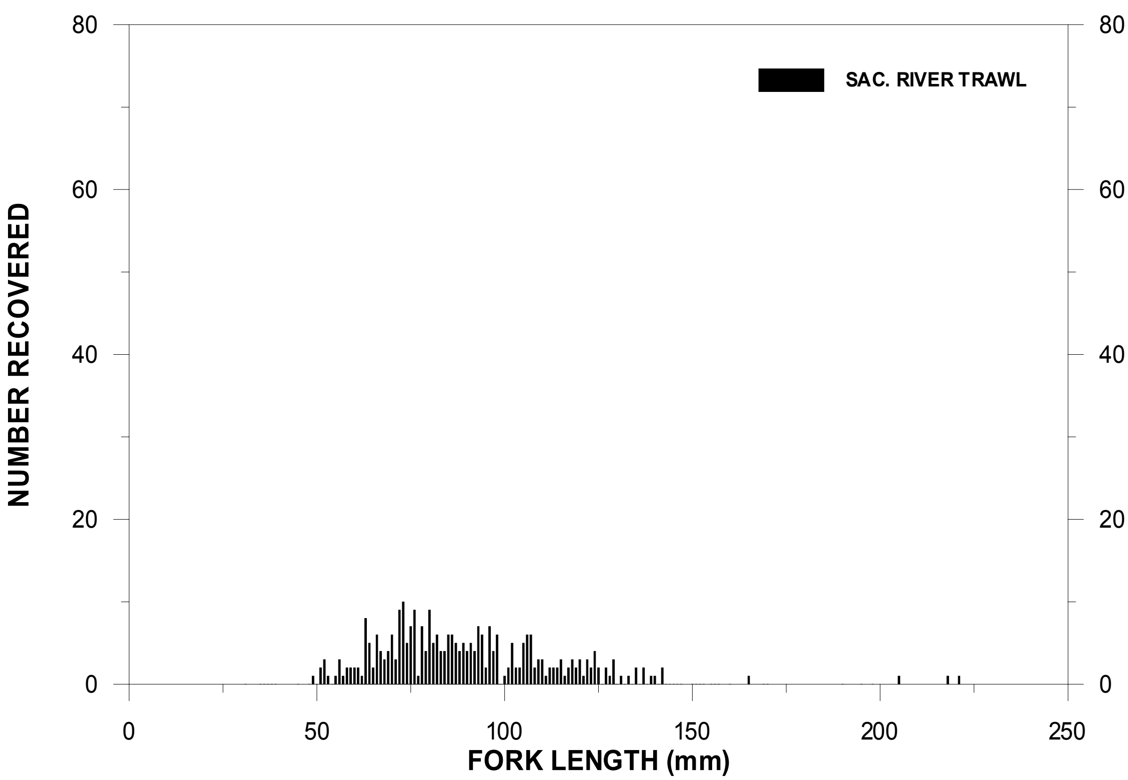
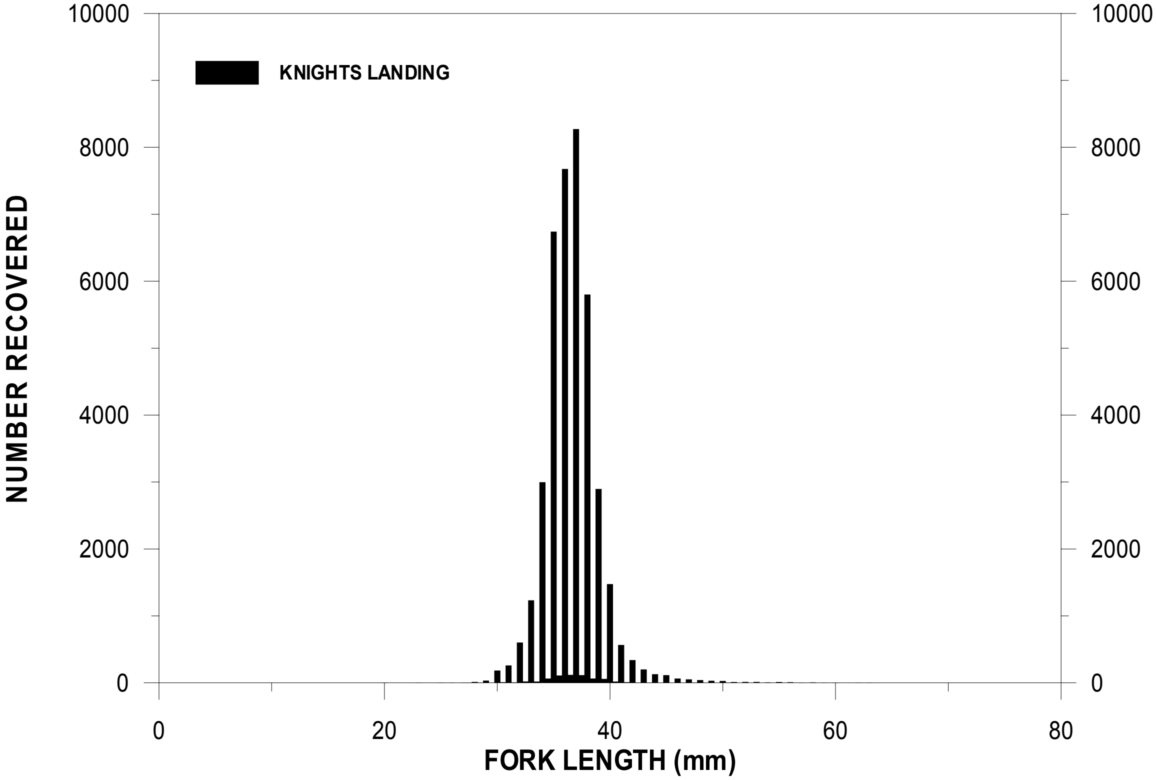


FIGURE 43.
NUMBER OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED VERSUS LENGTH, BETWEEN OCT TO JAN FOR WATER YEARS 1995 - 1999



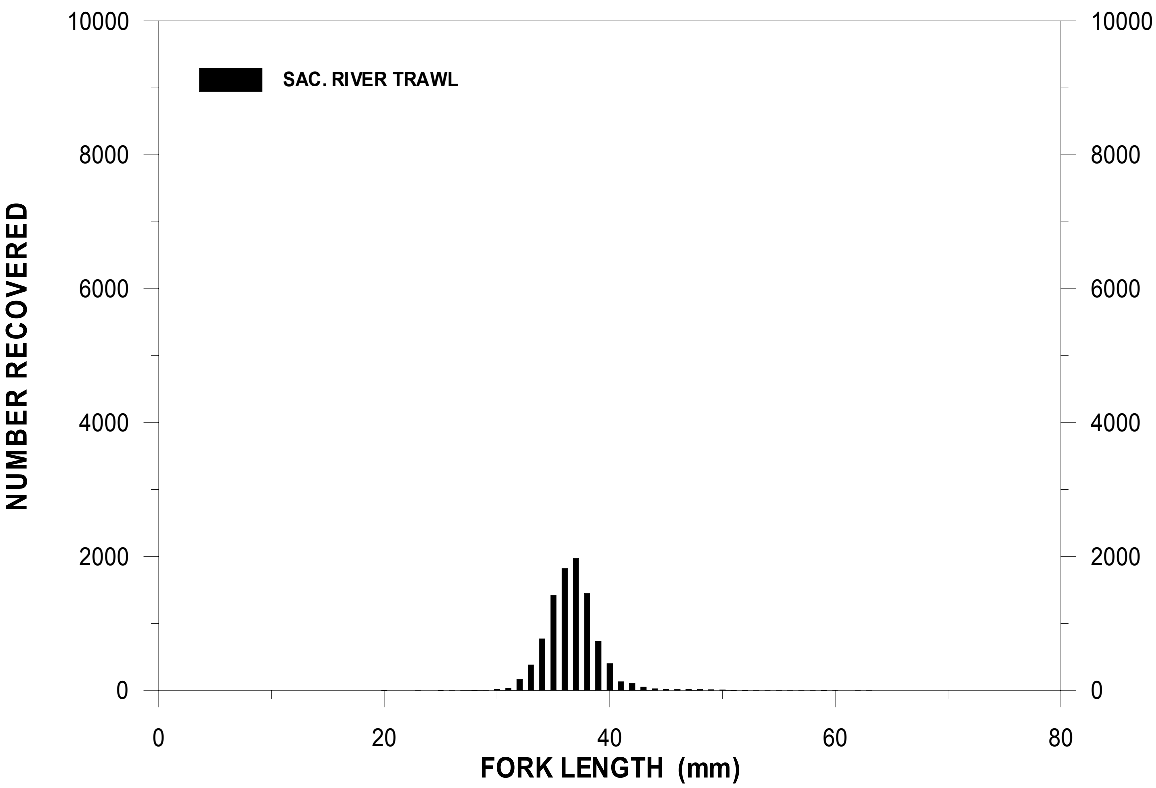


FIGURE 44.
CATCH OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, BETWEEN OCT & JAN, WATER YEARS 1996 - 1999

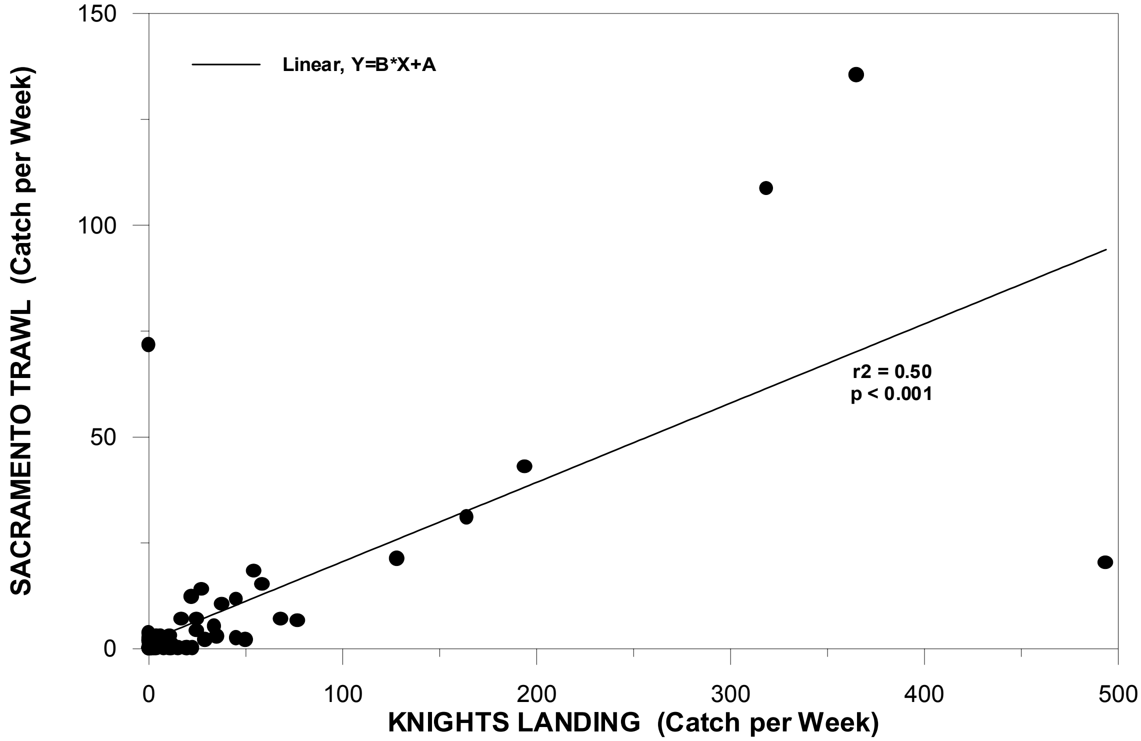
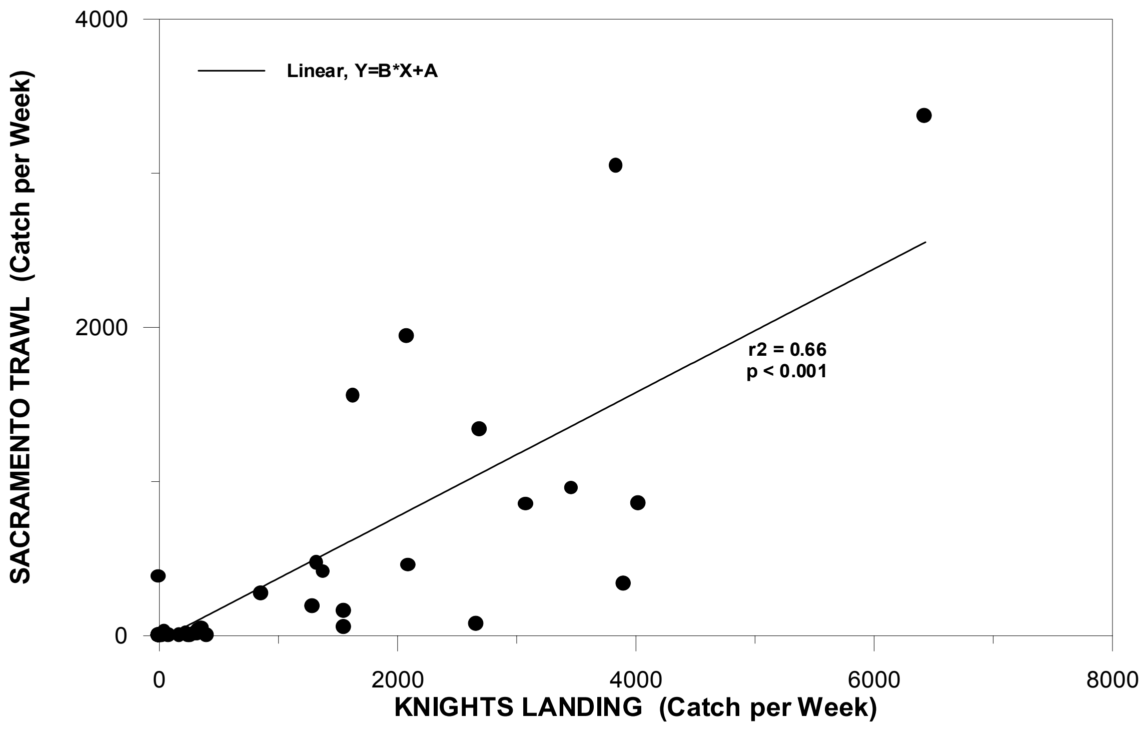


FIGURE 45.
CATCH OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, BETWEEN OCT & JAN, WATER YEARS 1996 - 1999



17 May 00

Table 25: Proportional abundances of fish species appearing in major FWS juvenile salmon migration study databases, and uses not involving salmonids to which the data are being put. Numbers after common names of nonindigenous species indicate dates of introduction. Shaded rows indicate species proposed for shallow water status and trends monitoring by CMARP shallow water fishes work group.

Column Heads:

Nat. Hist. natural history, as follows:
- **A** anadromous
- **E** euryhaline (may be found in marine, brackish, and freshwater habitats)
- **F** freshwater
- **M** marine

SB minnow seine in CDFG San Francisco Bay Study, 1980—1986
SD minnow seine in the Delta 1994—1998
CMWTR Chipps Island midwater trawl 1976—1999
S + T are/will these data used for status and trends monitoring?
Res. are these data used for research?

Proportional Abundance (PA) Categories:

Symbol	Range
–	not observed
I	0 < PA < 0.01
II	0.01 ≤ PA < 0.05
III	0.05 ≤ PA < 0.10
IV	0.10 ≤ PA < 0.25
V	0.25 ≤ PA

Taxon	Nat.Hist.	Sampling Program			Seine		CMWTR		Investigators
		SB	SD	CMWTR	S+T	Res.	S+T	Res.	
Cl. CEPHALASPIDOMORPHI									
O. Petromyzontiformes									
Petromyzontidae									
Lampetra ayresi (river lamprey)	A	–	I	I					
Lampetra tridentata (Pacific lamprey)	A	–	I	I					
Cl. CHONDRICHTHYES									
O. Carcharhiniformes									
Triakidae									
Triakis semifasciata (leopard shark)	M	I	–	–					
O. Rajiformes									
Myliobatidae									
Myliobatis californica (bat ray)	M	I	–	–					
Cl. OSTEICHTHYES									
O. Acipenseriformes									
Acipenseridae									
Acipenser transmontanus (white sturgeon)	E	–	–	I					
Acipenser medirostris (green sturgeon)	E	–	–	I					

Taxon	Nat.Hist.	Sampling Program			Seine		CMWTR		Investigators
		SB	SD	CMWTR	S+T	Res.	S+T	Res.	
O. Clupeiformes									
Engraulidae									
Engraulis mordax (northern anchovy)	M	**IV**	**I**	**V**	**Y**		**Y?**		**Chotkowski (seine)**
Clupeidae									
Alosa sapidissima (American shad, 1871)	E	**I**	**I**	**III**	**Y**		**Y?**		**Chotkowski (seine)**
Clupea pallasi (Pacific herring)	M	**–**	**I**	**IV**	**Y**	**Y**	**n/a**	**n/a**	**Baxter (seine)**
Dorosoma petenense (threadfin shad, 1961)	E	**I**	**IV**	**II**	**Y**		**Y?**		**Chotkowski (seine)**
Sardinops sagax (Pacific sardine)	M	**I**	**–**	**–**					
O. Cypriniformes									
Cyprinidae									
Carassius auratus (goldfish, 1963)	F	**–**	**I**	**I**	**Y**				
Cyprinella lutrensis (red shiner, 1980)	F	**–**	**IV**	**–**	**Y**				**Chotkowski (seine)**
Cyprinus carpio (common carp, 1917)	F	**I**	**I**	**I**	**Y**				
Hesperoleucus symmetricus (California roach)	F	**–**	**I**	**I**					
Lavinia exilicauda (hitch)	F	**I**	**I**	**I**					
Mylopharodon conocephalus (hardhead)	F	**–**	**I**	**I**					
Notemigonus crysoleucas (golden shiner, 1964)	F	**–**	**I**	**I**	**Y**				
Orthodon microlepidotus (Sacramento blackfish)	F	**I**	**I**	**I**					
Pimephales promelas (fathead minnow, 1950s)	F	**–**	**II**	**–**	**Y**				
Pogonichthys macrolepidotus (splittail)	F	**I**	**II**	**II**	**Y**	**Y**	**Y**	**Y**	**Baxter (seine), Brady (all), Chotkowski (seine), Sommer (seine)**
Ptychocheilus grandis (Sacramento pikeminnow)	F	**I**	**II**	**I**	**Y**				**Chotkowski (seine)**
Catostomidae									
Catostomus occidentalis (Sacramento sucker)	F	**–**	**III**	**I**	**Y**				**Chotkowski (seine)**
O. Siluriformes									
Ictaluridae									
Ameiurus catus (white catfish, 1874)	F	**–**	**I**	**I**					
Ameiurus melas (black bullhead, 1874)	F	**–**	**I**	**I**					
Ameiurus natalis (yellow bullhead, 1874)	F	**–**	**I**	**I**					

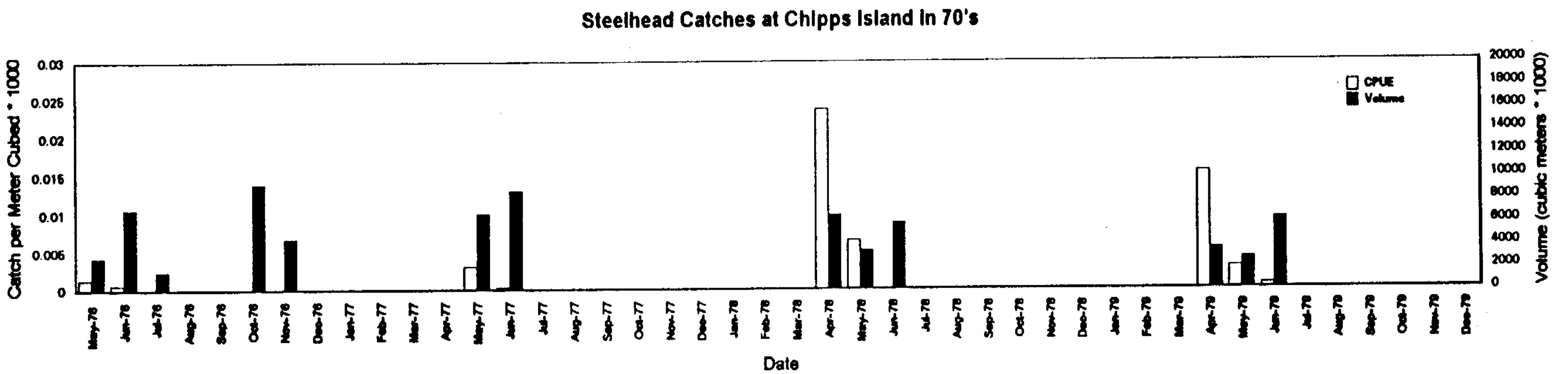
Taxon	Nat.Hist.	Sampling Program			Seine		CMWTR		Investigators
		SB	SD	CMWTR	S+T	Res.	S+T	Res.	
Ameiurus nebulosus (brown bullhead, 1874)	F	**–**	**I**	**I**					
Ictalurus punctatus (channel catfish, 1940s)	F	**–**	**I**	**I**					
O. Osmeriformes									
Osmeridae									
Hypomesus nipponensis (wakasagi, >1972)	F	**–**	**I**	**I**					
Hypomesus pretiosus (surf smelt)	E	**I**	**I**	**I**					
Hypomesus transpacificus (delta smelt)	E	**I**	**I**	**II**	**Y**	**Y**			**Bennett et al. (seine), Chotkowski (seine), Brady (all), Fleming (seine), Sitts? (seine)**
Spirinchus starksi (night smelt)	M	**I**	**–**	**–**					
Spirinchus thaleichthys (longfin smelt)	E	**I**	**I**	**III**			**Y**	**Y**	**Baxter? (trawl)**
O. Salmoniformes									
Salmonidae									
Oncorhynchus mykiss (steelhead)	A	**I**	**I**	**I**	**n/a**		**n/a**		
Oncorhynchus tshawytscha (chinook salmon)	A	**I**	**IV**	**IV**	**n/a**	**Y**	**n/a**	**Y**	**Feyrer (all), Kimmerer (all), Sommer (all),**
O. Batrachoidiformes									
Batrachoididae									
Porichthys notatus (plainfin midshipman)	M	**I**	**–**	**I**					
O. Mugiliformes									
Mugilidae									
Mugil cephalus (striped mullet)	E	**I**	**–**	**–**					
O. Atheriniformes									
Atherinidae									
Atherinops affinis (topsmelt)	M	**V**	**I**	**I**	**Y**	**Y**			**Baxter (seine)**
Atherinopsis californiensis (jacksmelt)	M	**IV**	**I**	**I**	**Y**				
Menidia beryllina (inland silverside, 1971)	E	**I**	**V**	**I**	**Y**	**Y**	**Y**	**Y?**	**Bennett (seine), Chotkowski (seine)**
O. Cyprinodontiformes									
Poeciliidae									
Gambusia affinis (western mosquitofish, 1965)	E	**I**	**II**	**I**	**Y**				

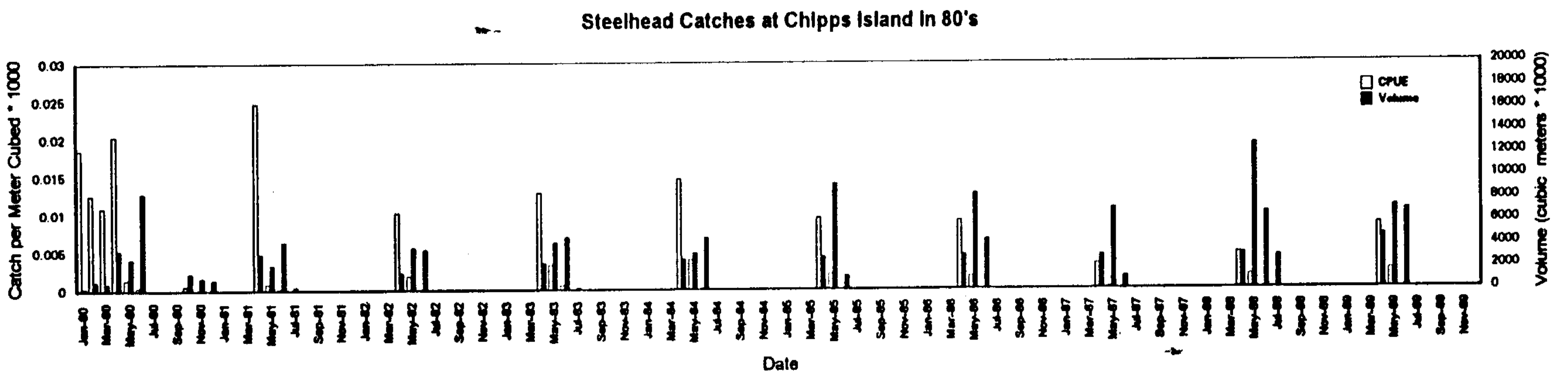
Taxon	Nat.Hist.	Sampling Program			Seine		CMWTR		Investigators
		SB	SD	CMWTR	S+T	Res.	S+T	Res.	
Cyprinodontidae									
Lucania parva (rainwater killifish, 1958)	E	**I**	**I**	**I**					
O. Gasterosteiformes									
Gasterosteidae									
Gasterosteus aculeatus (threespine stickleback)	E	**II**	**I**	**I**	**Y**				
Syngnathidae									
Syngnathus leptorhynchus (bay pipefish)	E	**II**	**I**	**I**					
O. Scorpaeniformes									
Scorpaenidae									
Sebastes auriculatus (brown rockfish)	M	**I**	**–**	**–**					
Hexagrammidae									
Hexagrammos decagrammus (kelp greenling)	M	**I**	**–**	**–**					
Cottidae									
Cottus asper (prickly sculpin)	E	**I**	**I**	**I**					
Cottus gulosus (riffle sculpin)	F	**–**	**I**	**–**					
Leptocottus armatus (Pacific staghorn sculpin)	E	**III**	**I**	**I**	**Y**	**Y**			**Baxter (seine)**
Oligocottus snyderi (fluffy sculpin)	M	**I**	**–**	**–**					
Scorpaenichthys marmoratus (cabezon)	M	**I**	**–**	**–**					
O. Perciformes									
Percichthyidae									
Morone saxatilis (striped bass, 1879)	E	**III**	**I**	**III**	**Y?**	**?**	**Y?**	**?**	
Centrarchidae									
Lepomis cyanellus (green sunfish, 1964)	F	**–**	**I**	**I**	**Y?**	**Y**			**Chotkowski and Nobriga (seine)**
Lepomis gulosus (warmouth, >1921)	F	**–**	**I**	**I**					**Chotkowski and Nobriga (seine)**
Lepomis macrochirus (bluegill, 1908)	F	**–**	**I**	**I**	**Y?**	**Y**			**Chotkowski and Nobriga (seine)**
Lepomis microlophus (redear sunfish, >1949)	F	**–**	**I**	**I**	**Y?**	**Y**			**Chotkowski and Nobriga (seine)**

Taxon	Nat.Hist.	Sampling Program			Seine		CMWTR		Investigators
		SB	SD	CMWTR	S+T	Res.	S+T	Res.	
Micropterus dolomieu (smallmouth bass, ≤1948)	F	–	I	I		Y			**Chotkowski and Nobriga (seine)**
Micropterus salmoides (largemouth bass, ≤1948)	F	–	I	I	Y?	Y			**Chotkowski and Nobriga (seine)**
Pomoxis annularis (white crappie, 1951)	F	–	I	I	Y?	Y			**Chotkowski and Nobriga**
Pomoxis nigromaculatus (black crappie, 1908)	F	–	I	I	Y?	Y			**Chotkowski and Nobriga (seine)**
Percidae									
Percina macrolepida (bigscale logperch, 1973)	F	I	I	I	Y				
Sciaenidae									
Genyonemus lineatus (white croaker)	M	I	–	I					
Embiotocidae									
Amphistichus argenteus (barred surfperch)	M	I	–	–					**Baxter (seine)**
Amphistichus koelzi (calico surfperch)	M	I	–	–					**Baxter (seine)**
Cymatogaster aggregata (shiner perch)	E	III	I	I	Y?	Y			**Baxter (seine), Chotkowski (seine)**
Embiotoca jacksoni (black perch)	M	I	–	–					**Baxter (seine)**
Hyperprosopon argenteum (walleye surfperch)	M	I	–	–					**Baxter (seine)**
Hyperprosopon ellipticum (silver surfperch)	M	I	–	I					**Baxter (seine)**
Hysterocarpus traski (tule perch)	F	I	I	I	Y	Y			**Chotkowski and Nobriga (seine)**
Micrometrus minimus (dwarf perch)	M	III	–	–	Y?				**Baxter (seine)**
Phanerodon furcatus (white seaperch)	M	I	–	–					**Baxter (seine)**
Rhacochilus toxotes (rubberlip seaperch)	M	I	–	–					**Baxter (seine)**
Rhacochilus vacca (pile perch)	M	I	–	–					**Baxter (seine)**
Pholidae									
Apodichthys flavidus (penpoint gunnel)	M	I	–	–					
Pholis ornata (saddleback gunnel)	M	I	–	–					
Ammodytidae									
Ammodytes hexapterus (Pacific sand lance)	M	I	–	–					
Clinidae									
Gibbonsia metzi (striped kelpfish)	M	I	–	–					

Taxon	Nat.Hist.	Sampling Program			Seine		CMWTR		Investigators
		SB	SD	CMWTR	S+T	Res.	S+T	Res.	
Blenniidae									
Hypsoblennius gilberti (rockpool blenny)	M	**I**	**–**	**–**					
Gobiidae									
Acanthogobius flavimanus (yellowfin goby, 1963)	E	**III**	**I**	**I**	**Y**				
Clevelandia ios (arrow goby)	E	**III**	**I**	**–**	**Y**				
Gillichthys mirabilis (longjaw mudsucker)	E	**I**	**–**	**I**					
Ilypnus gilberti (cheekspot goby)	M	**I**	**–**	**I**					
Lepidogobius lepidus (bay goby)	M	**I**	**–**	**–**					
Tridentiger bifasciatus (shimofuri goby, 1985)	E	**–**	**I**	**I**					
Tridentiger trigonocephalus (chameleon goby, 1962)	M	**I**	**I**	**I**					
O. Pleuronectiformes									
Paralichthyidae									
Citharichthys stigmaeus (speckled sanddab)	M	**I**	**I**	**I**					
Paralichthys californicus (California halibut)	M	**I**	**–**	**–**		**Y**			**Baxter (seine)**
Pleuronectidae									
Hypsopsetta guttulata (diamond turbot)	M	**I**	**I**	**I**					
Platichthys stellatus (starry flounder)	E	**I**	**I**	**I**	**Y**	**Y**			**Baxter (seine)**
Pleuronectes vetulus (English sole)	M	**I**	**I**	**I**					
Psettichthys melanostictus (sand sole)	M	**I**	**–**	**–**					

Figure 46 a,b,c





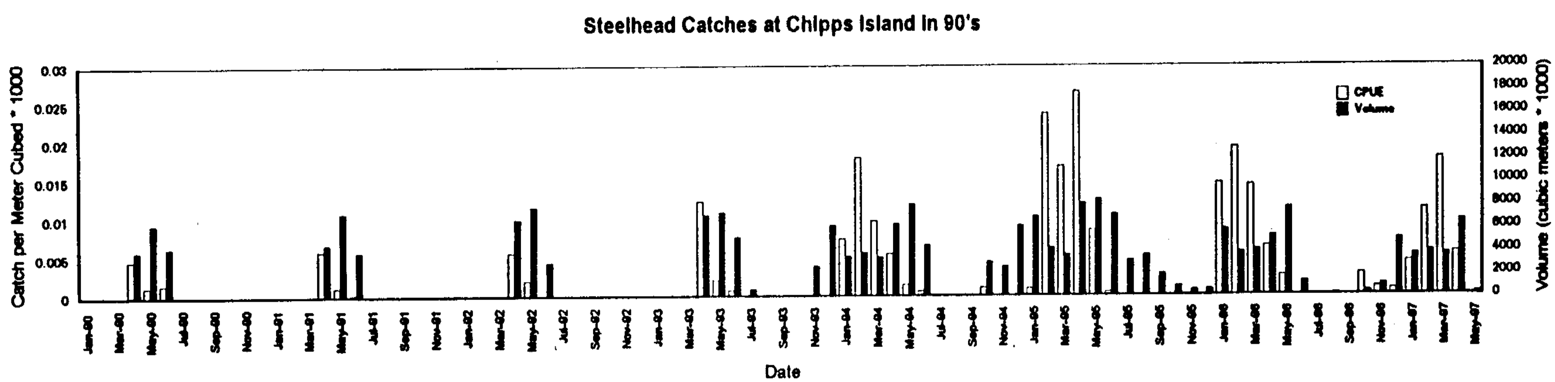
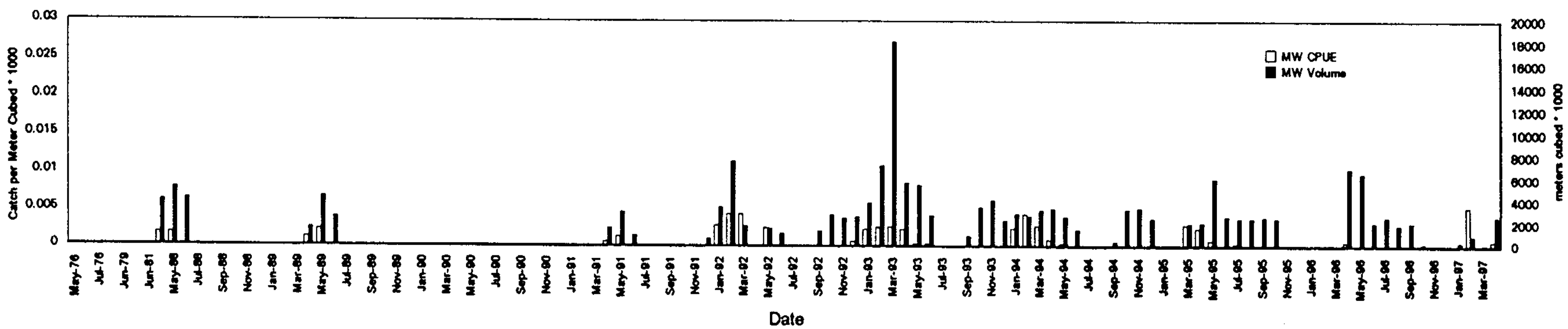
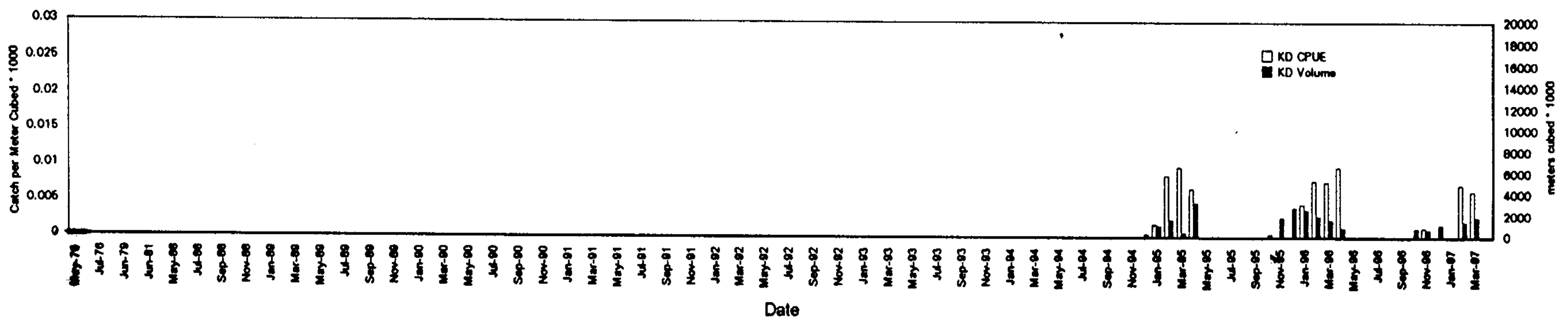


Figure 47 a,b,c

Steelhead Sacramento Midwater Trawl



Steelhead Sacramento Kodiak Trawl



Steelhead Hood and Clarksburg Midwater Trawl

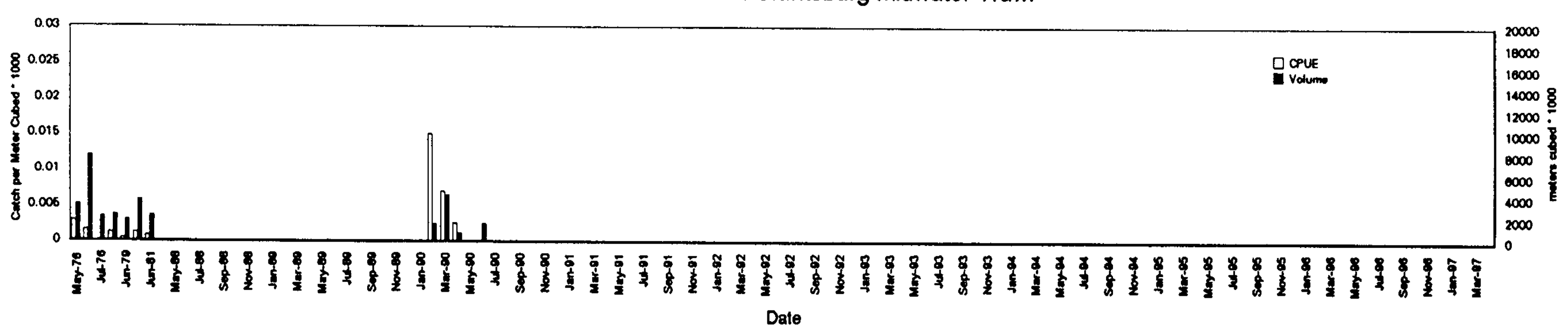
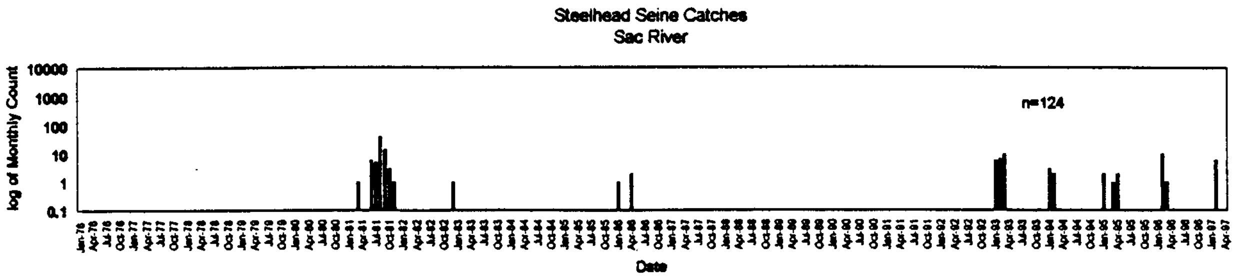
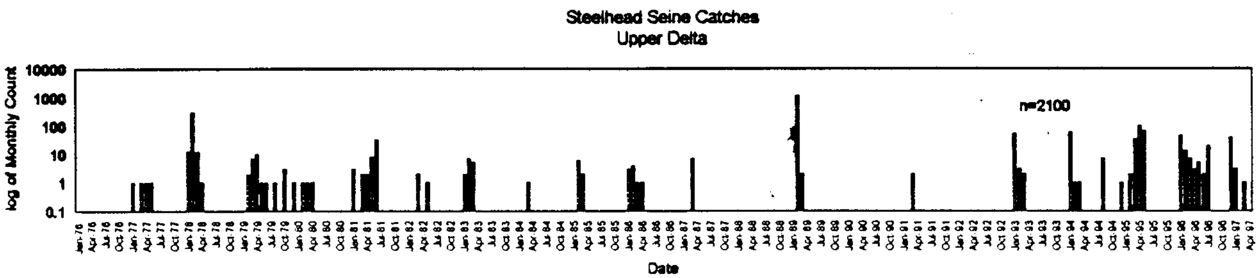


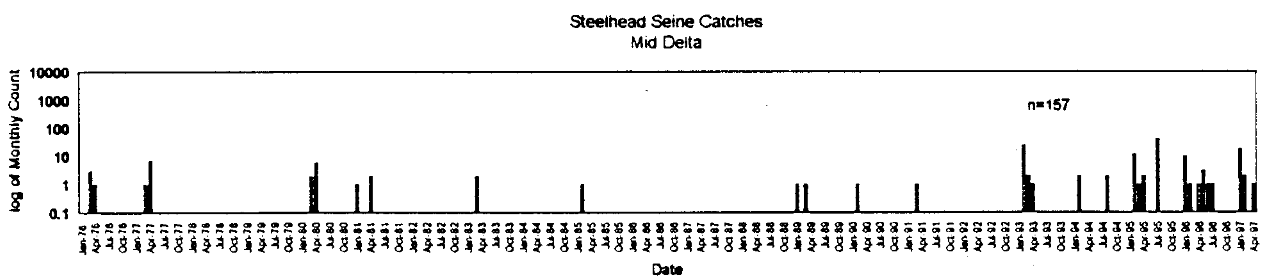
Figure 48



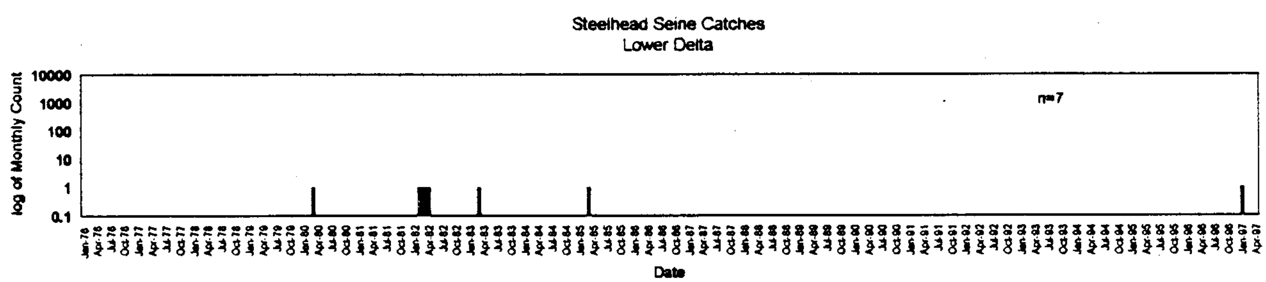
Steelhead Seine Catches
Sac River
log of Monthly Count
n=124
Date



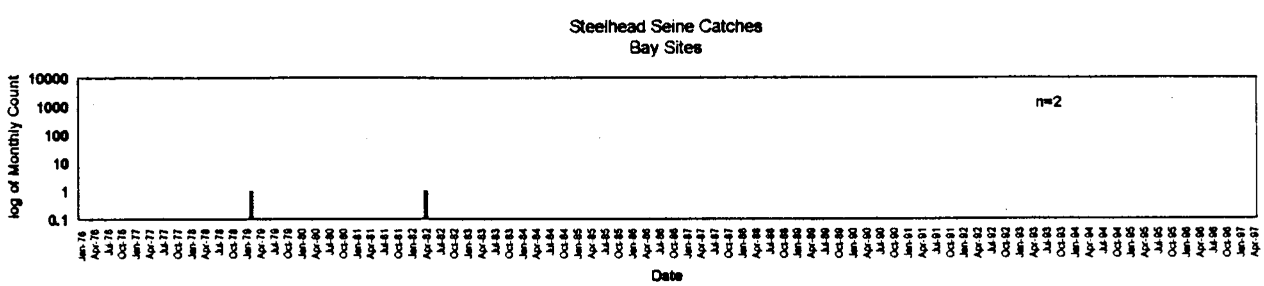
Steelhead Seine Catches
Upper Delta
log of Monthly Count
n=2100
Date



Steelhead Seine Catches
Mid Delta
log of Monthly Count
n=157
Date

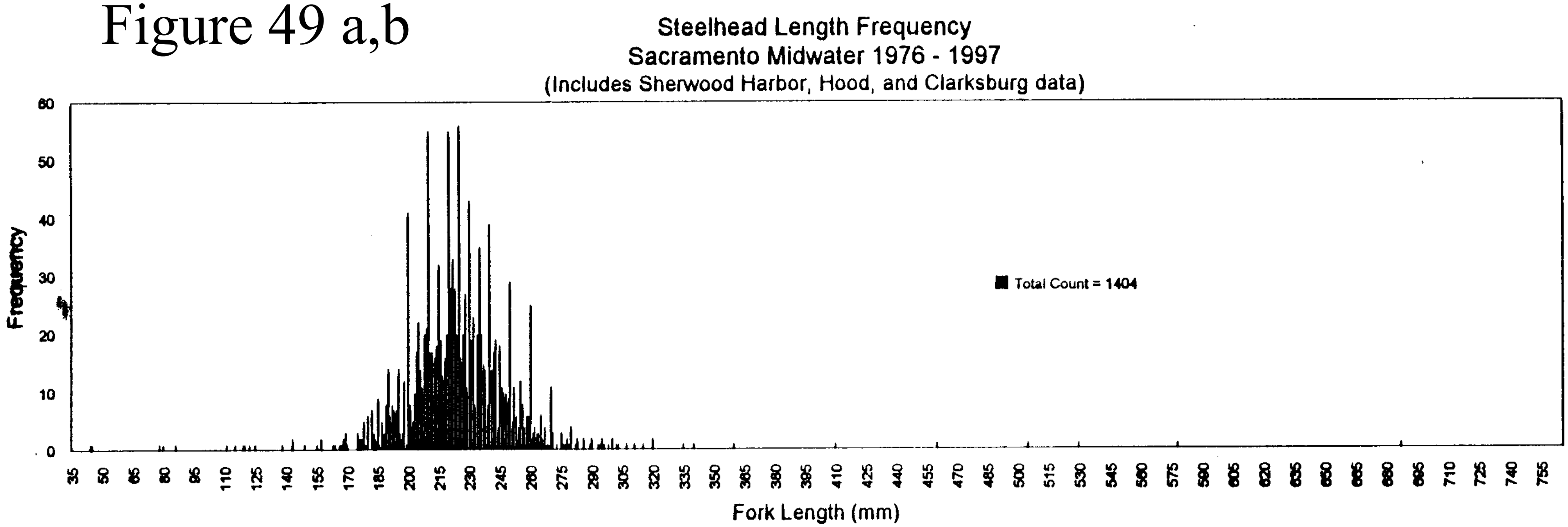


Steelhead Seine Catches
Lower Delta
log of Monthly Count
n=7
Date



Steelhead Seine Catches
Bay Sites
log of Monthly Count
n=2
Date

Figure 49 a,b


Steelhead Length Frequency
Sacramento Midwater 1976 - 1997
(Includes Sherwood Harbor, Hood, and Clarksburg data)
Frequency
Fork Length (mm)
Total Count = 1404

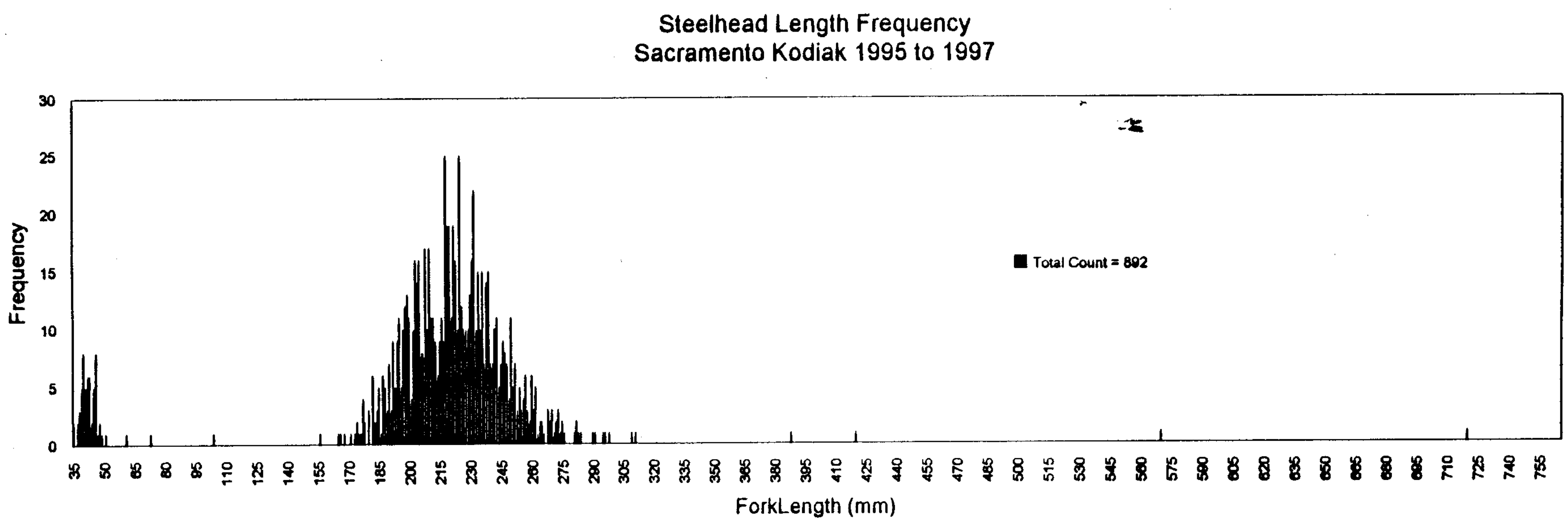

Steelhead Length Frequency
Sacramento Kodiak 1995 to 1997
Frequency
ForkLength (mm)
Total Count = 892

Figure 50

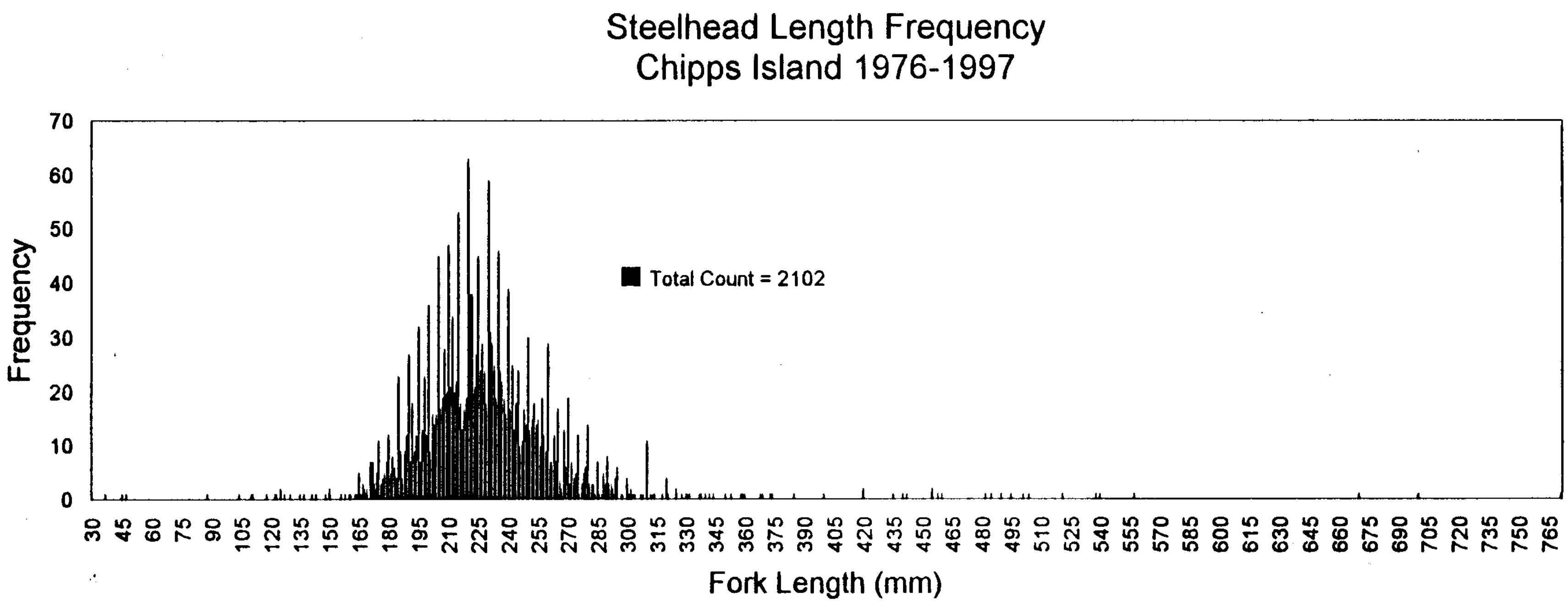
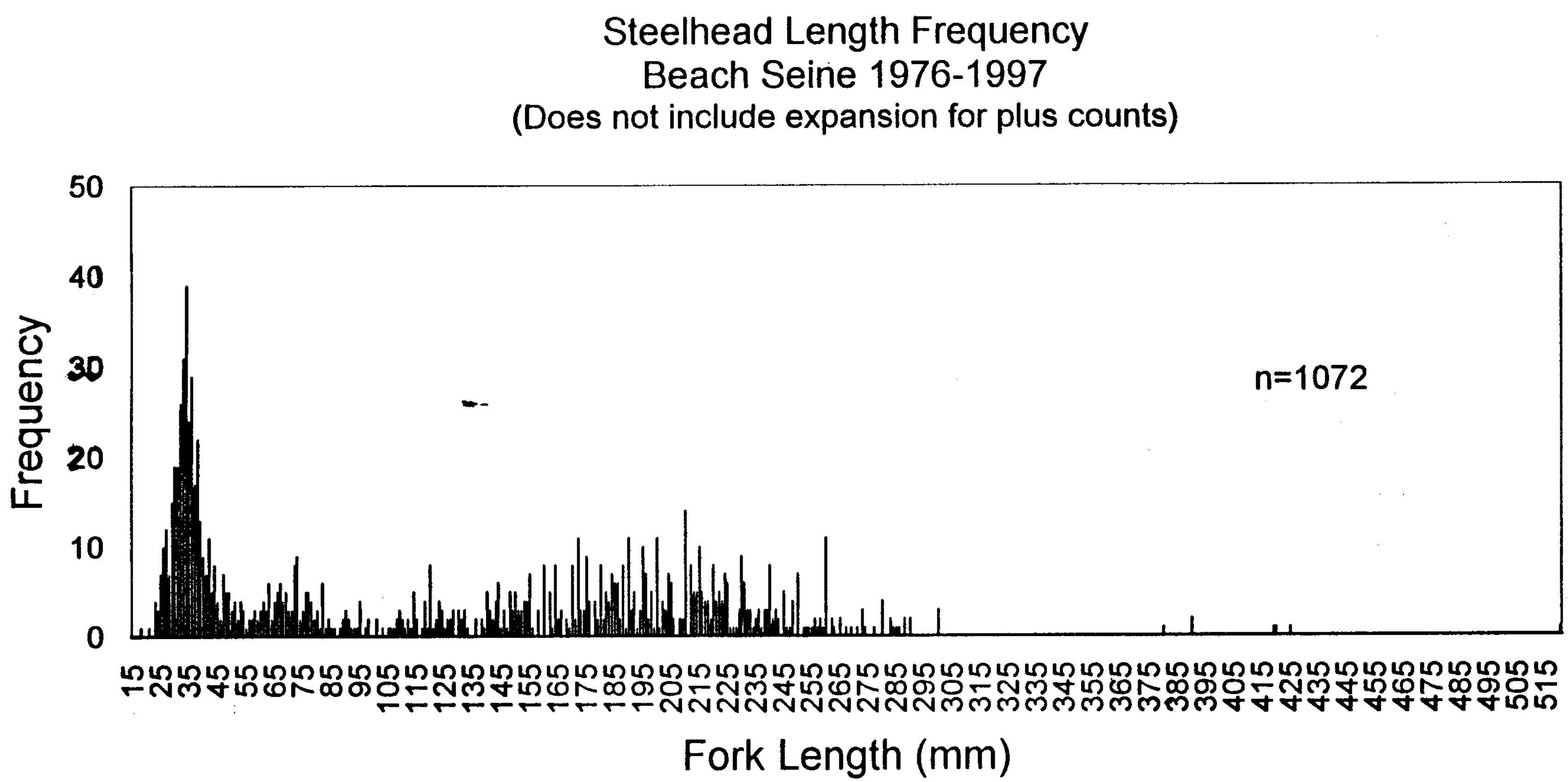

Steelhead Length Frequency
Chipps Island 1976-1997
Total Count = 2102
Frequency
0
10
20
30
40
50
60
70
Fork Length (mm)
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
360
375
390
405
420
435
450
465
480
495
510
525
540
555
570
585
600
615
630
645
660
675
690
705
720
735
750
765

Figure 51



Steelhead Length Frequency
Beach Seine 1976-1997
(Does not include expansion for plus counts)
50
40
30
20
10
0
Frequency
n=1072
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
185
195
205
215
225
235
245
255
265
275
285
295
305
315
325
335
345
355
365
375
385
395
405
415
425
435
445
455
465
475
485
495
505
515
Fork Length (mm)

Figure 52. Sacramento Kodiak Trawl Steelhead Distribution Frequency, 1995 -1999.

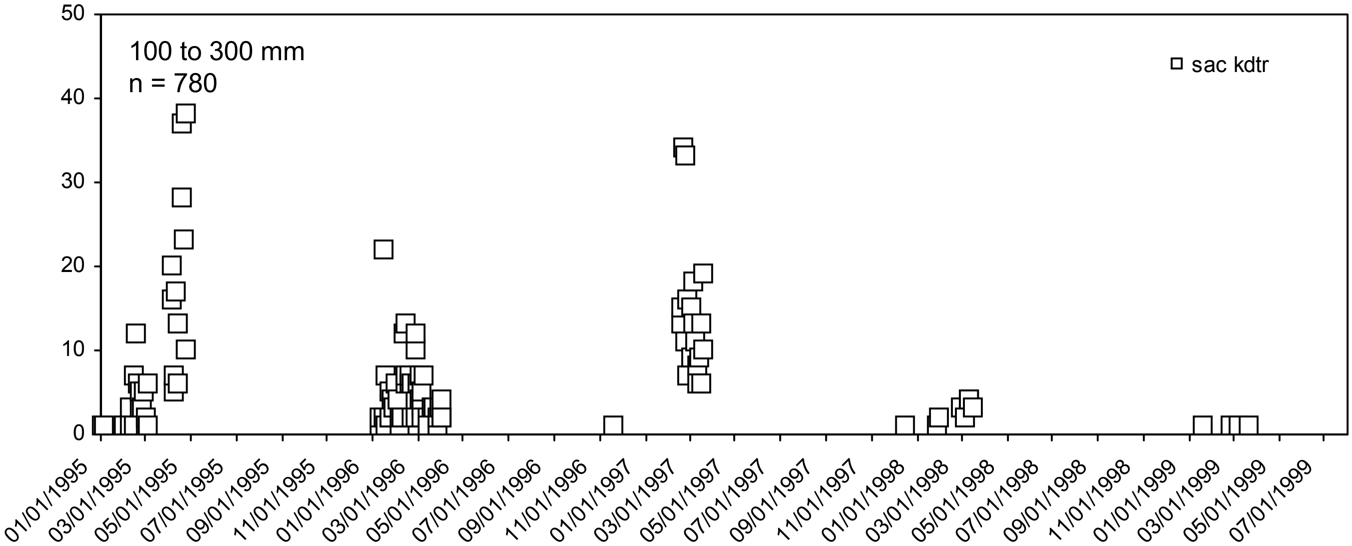


Figure 53. Sacramento Midwater Trawl Steelhead Distribution Frequency, 1995 - 1999.

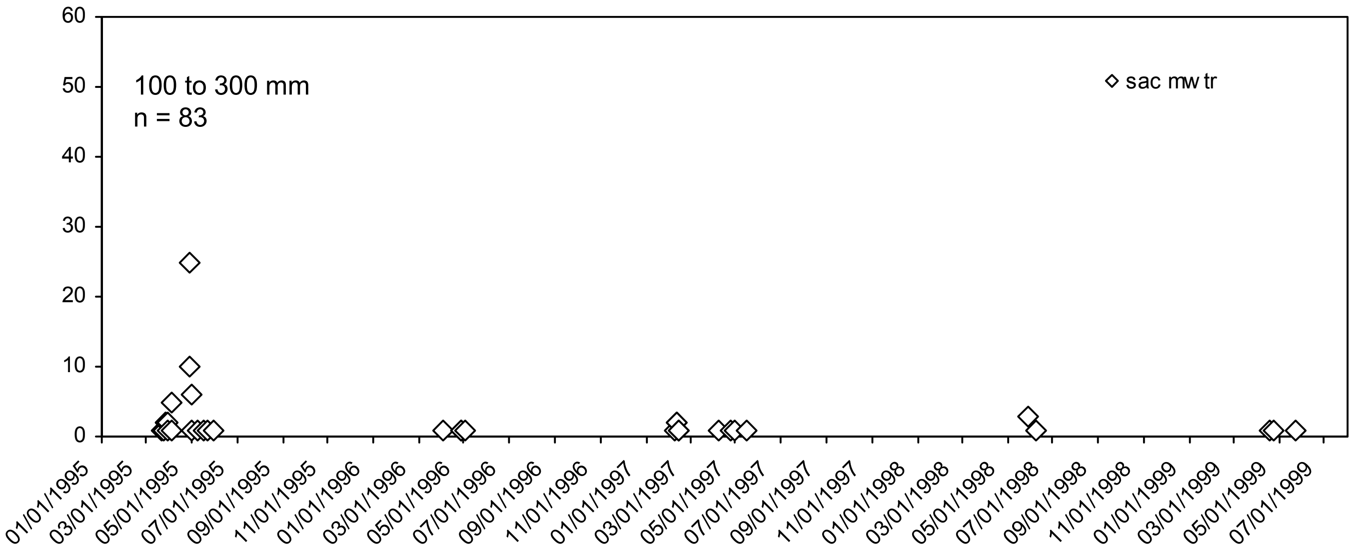
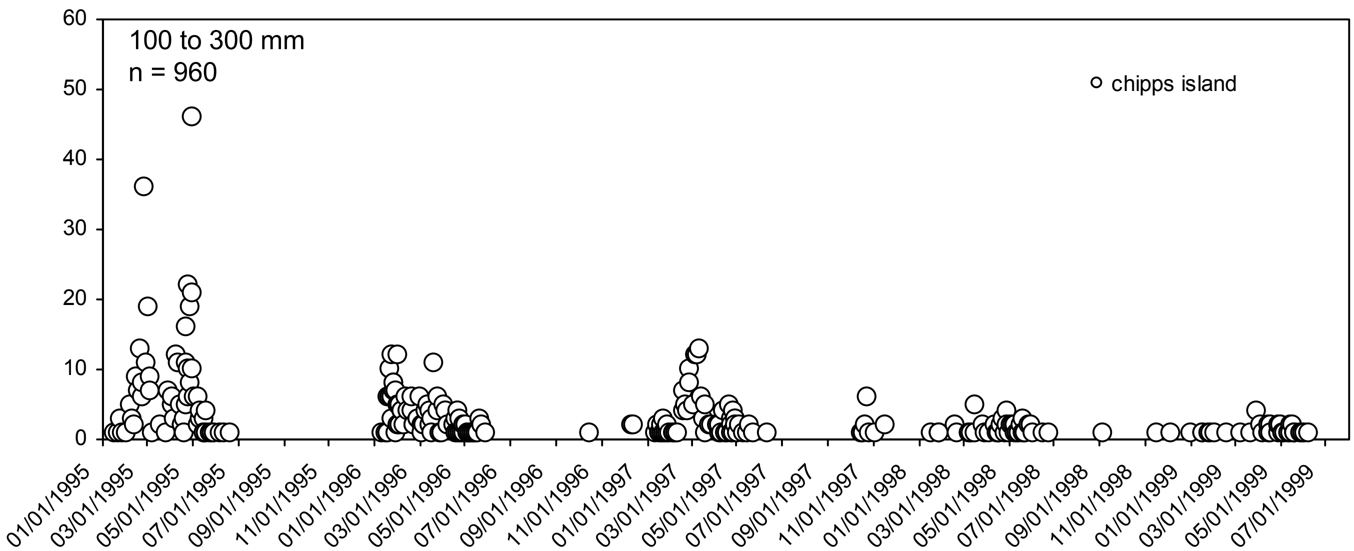


Figure 54. Chipps Island Midwater Trawl Steelhead Distribution Frequency, 1995 - 1999.



Regions 1, 2, 3, Steelhead Distribution Frequency, 1990 - 1999.

Figure 55a.

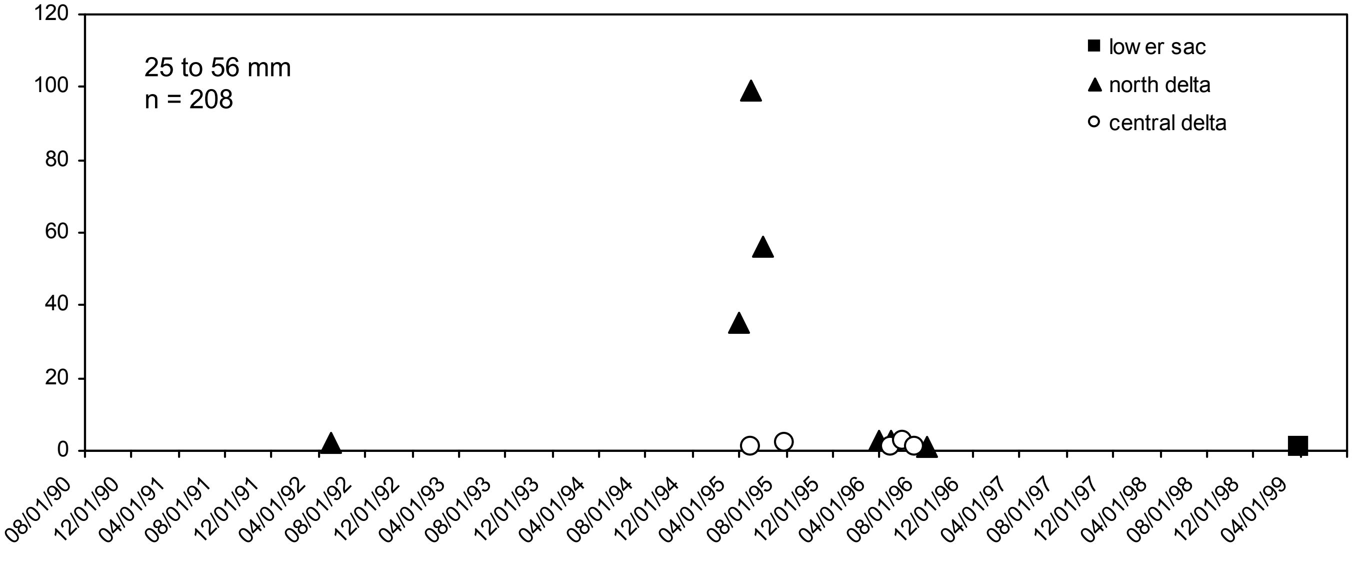
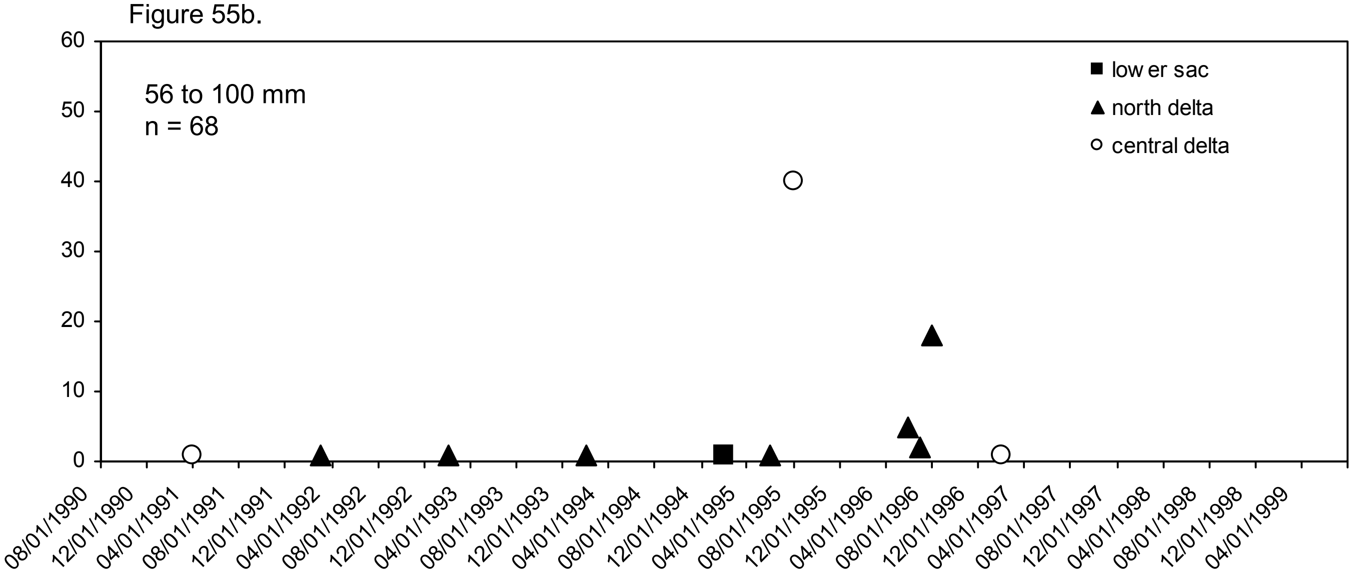


Figure 55b.



Regions 1, 2, 3, Steelhead Distribution Frequency, 1990 - 1999.

Figure 56.

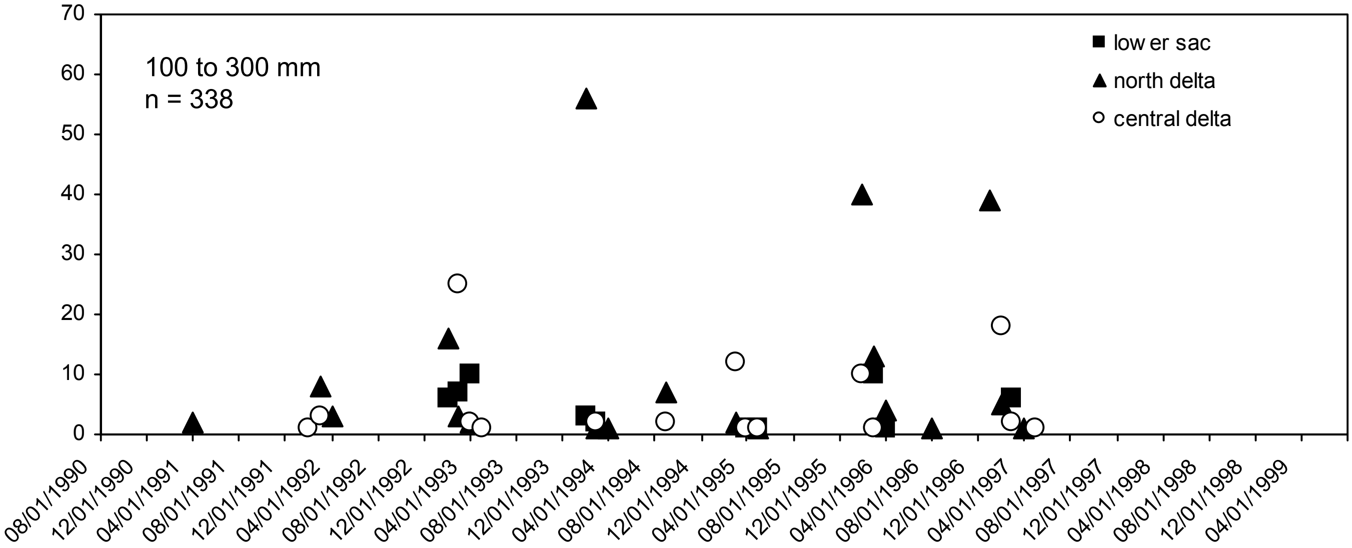
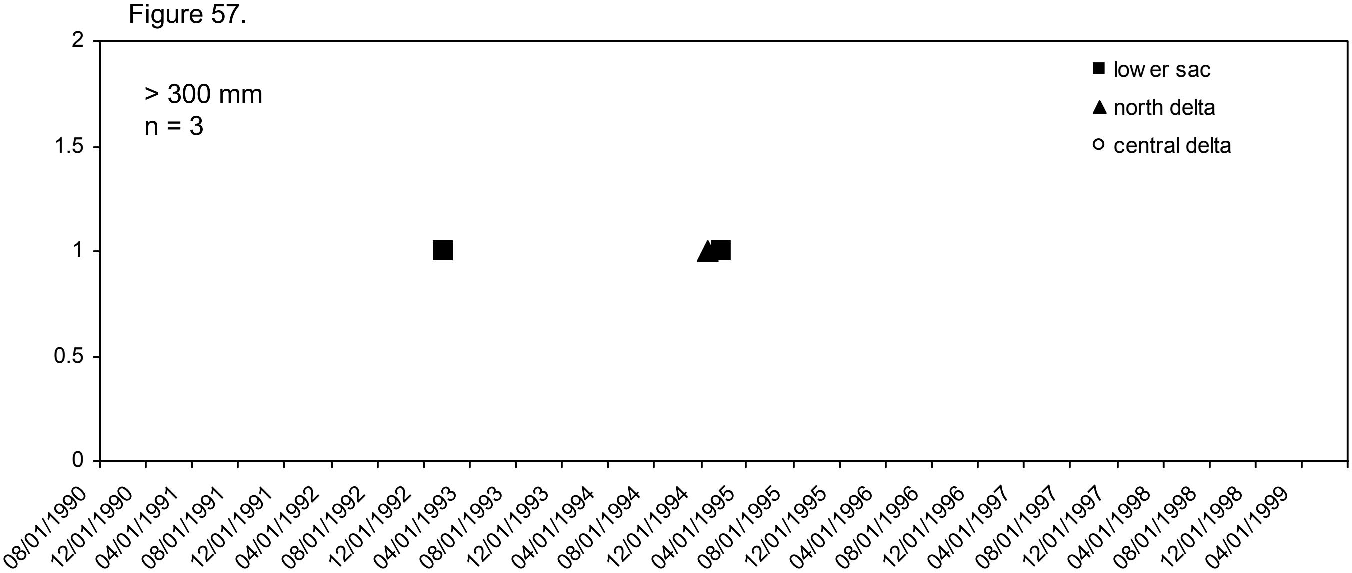


Figure 57.



APPENDIX 1
TABLE OF CONTENTS

Figure 15. Length distribution of chinook below the minimum winter run length line recovered in the Knights Landing rotary screw trap, December 1996

Figure 16. Length distribution of chinook below the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, December 1996

Figure 17. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, January 1997

Figure 18. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, January 1997
.
Figure 19. Length distribution of chinook below the minimum winter run length line recovered in the Knights Landing rotary screw trap, January 1997

Figure 20. Length distribution of chinook below the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, January 1997

Figure 21. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, October 1997

Figure 22. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, October 1997
.
Figure 23. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, November 1997
.
Figure 24. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, November 1997

Figure 25. Length distribution of chinook below the minimum winter run length line recovered in the Knights Landing rotary screw trap, November 1997

Figure 26. Length distribution of chinook below the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, November 1997

Figure 27. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, December 1997
.
Figure 28. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, December 1997

Figure 29. Length distribution of chinook below the minimum winter run length line recovered in the Knights Landing rotary screw trap, December 1997

Figure 30. Length distribution of chinook below the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, December 1997

Figure 31. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, January 1998
.
Figure 32. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, January 1998

Figure 33. Length distribution of chinook below the minimum winter run length line recovered in the Knights Landing rotary screw trap, January 1998

Figure 34. Length distribution of chinook below the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, January 1998

Figure 35. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, October 1998
.
Figure 36. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, October 1998

Figure 37. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, November 1998

Figure 38. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, November 1998

Figure 39. Length distribution of chinook below the minimum winter run length line recovered in the Knights Landing rotary screw trap, November 1998

Figure 40. Length distribution of chinook below the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, November 1998

Figure 41. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, December 1998

Figure 42. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, December 1998

Figure 43. Length distribution of chinook below the minimum winter run length line recovered in the Knights Landing rotary screw trap, December 1998

Figure 44. Length distribution of chinook below the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, December 1998

Figure 45. Length distribution of chinook above the minimum winter run length line recovered in the Knights Landing rotary screw trap, January 1999

Figure 46. Length distribution of chinook above the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, January 1999

Figure 47. Length distribution of chinook below the minimum winter run length line recovered in the Knights Landing rotary screw trap, January 1999
.

Figure 48. Length distribution of chinook below the minimum winter run length line recovered in the Sac. River Kodiak & Midwater trawls, January 1999

Figure 49. Catch of chinook above the minimum winter run length line, expanded for effort, October 1995 - January 1996

Figure 50. Catch of chinook below the minimum winter run length line, expanded for effort, October 1995 - January 1996

Figure 51. Catch of chinook above the minimum winter run length line, expanded for effort, October 1996 - January 1997

Figure 52. Catch of chinook below the minimum winter run length line, expanded for effort, October 1996 - January 1997

Figure 53. Catch of chinook above the minimum winter run length line, expanded for effort, October 1997 - January 1998

Figure 54. Catch of chinook below the minimum winter run length line, expanded for effort, October 1997 - January 1998

Figure 55. Catch of chinook above the minimum winter run length line, expanded for effort, October 1998 - January 1999

Figure 56. Catch of chinook below the minimum winter run length line, expanded for effort, October 1998 - January 1999

FIGURE 1. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, DECEMBER 1995

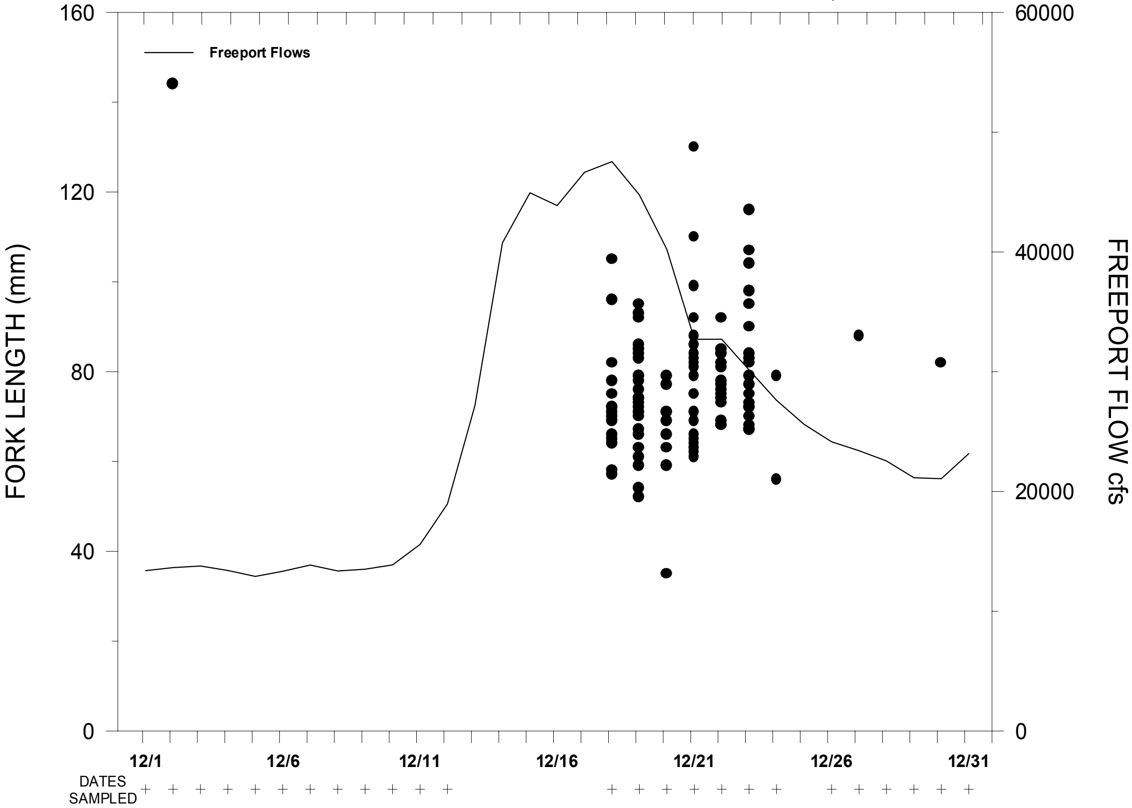


FIGURE 2. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, DECEMBER 1995

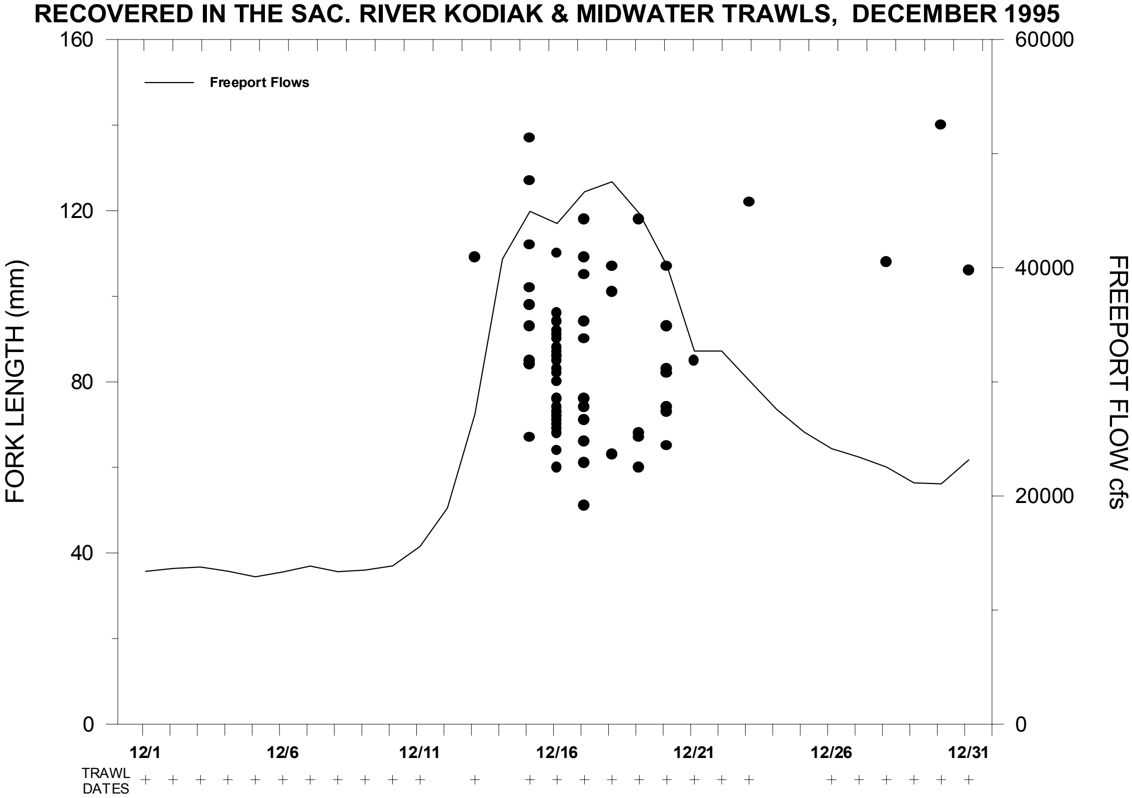


FIGURE 3. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, DECEMBER 1995

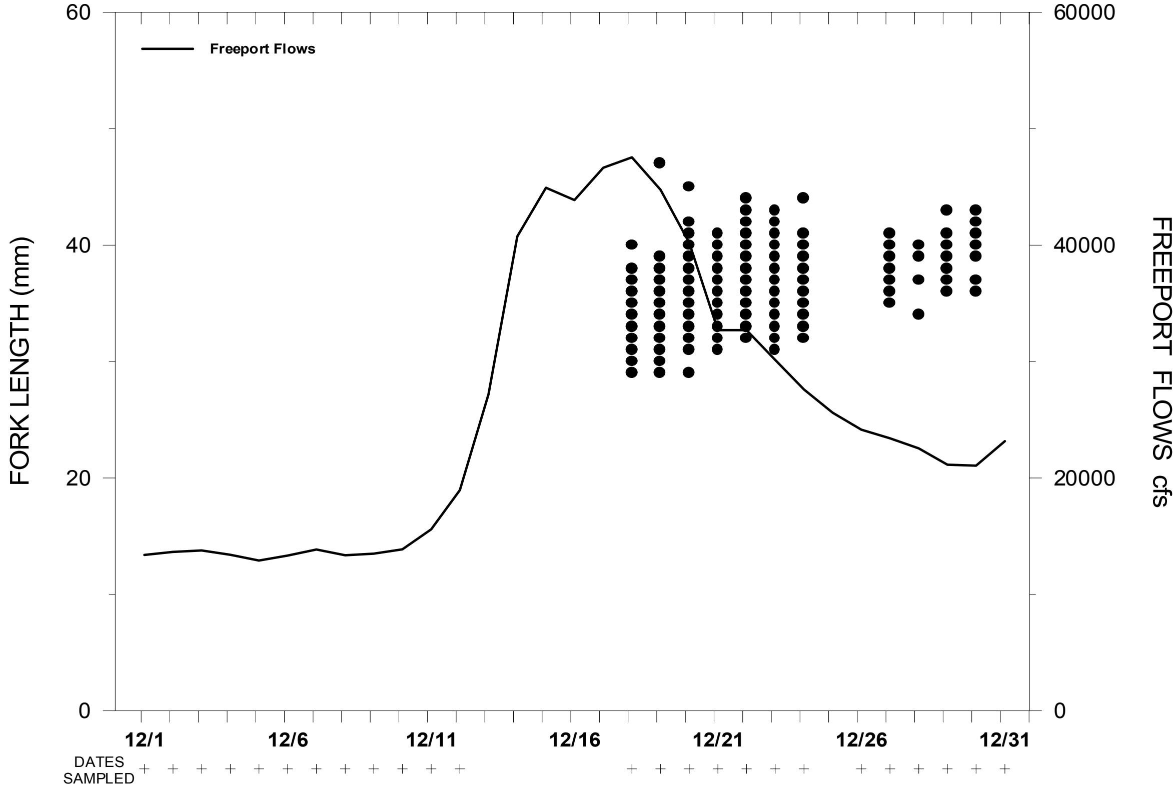


FIGURE 4. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, DECEMBER 1995

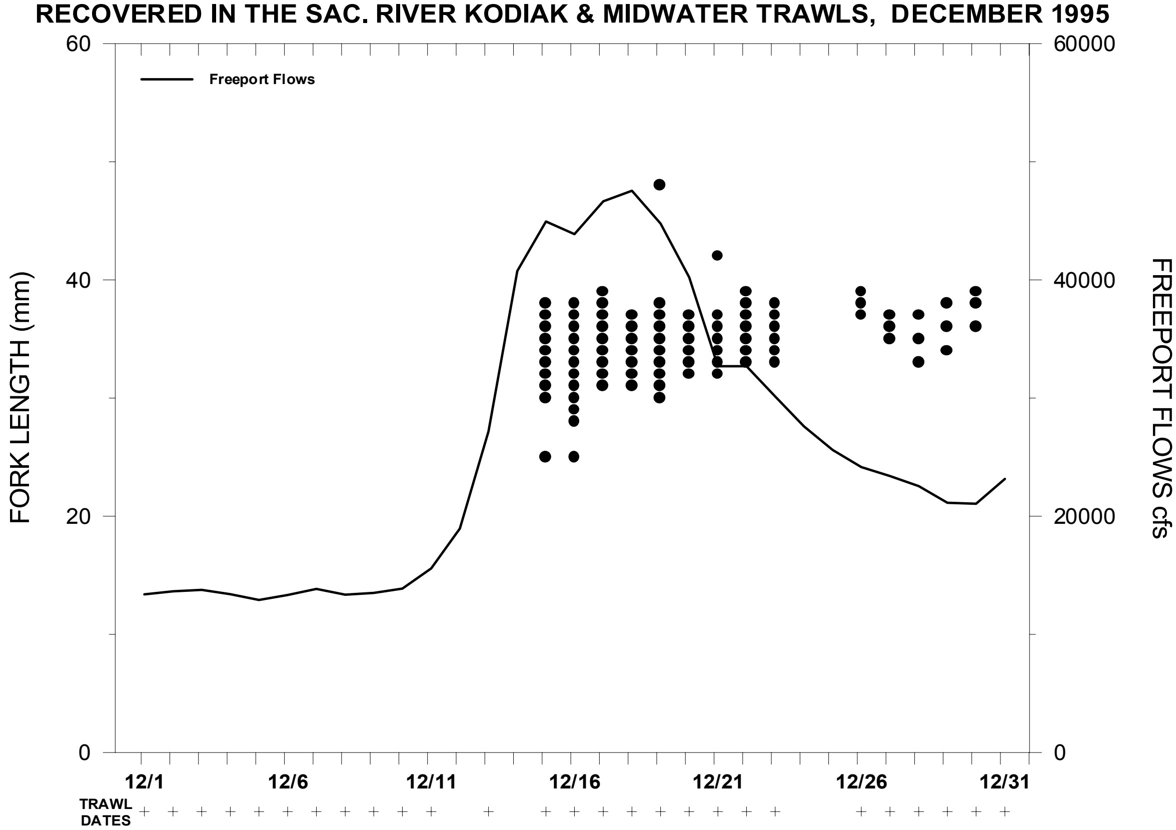


FIGURE 5. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, JANUARY 1996

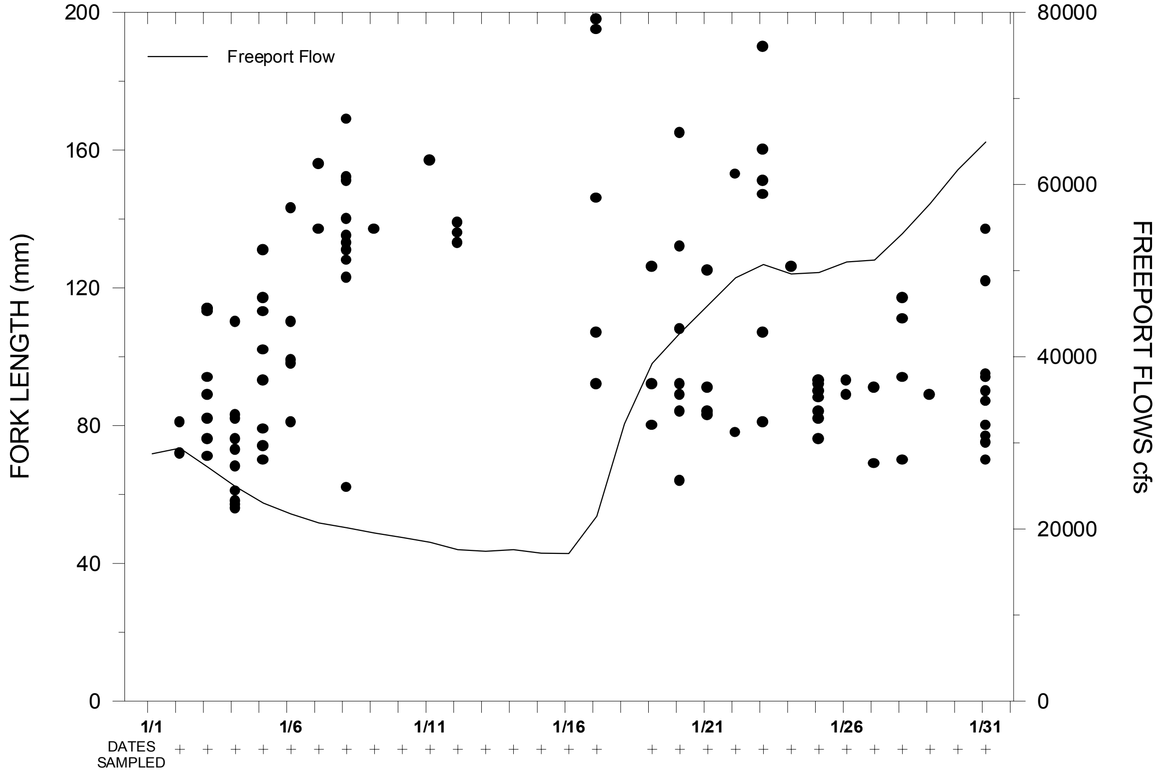


FIGURE 6. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, JANUARY 1996

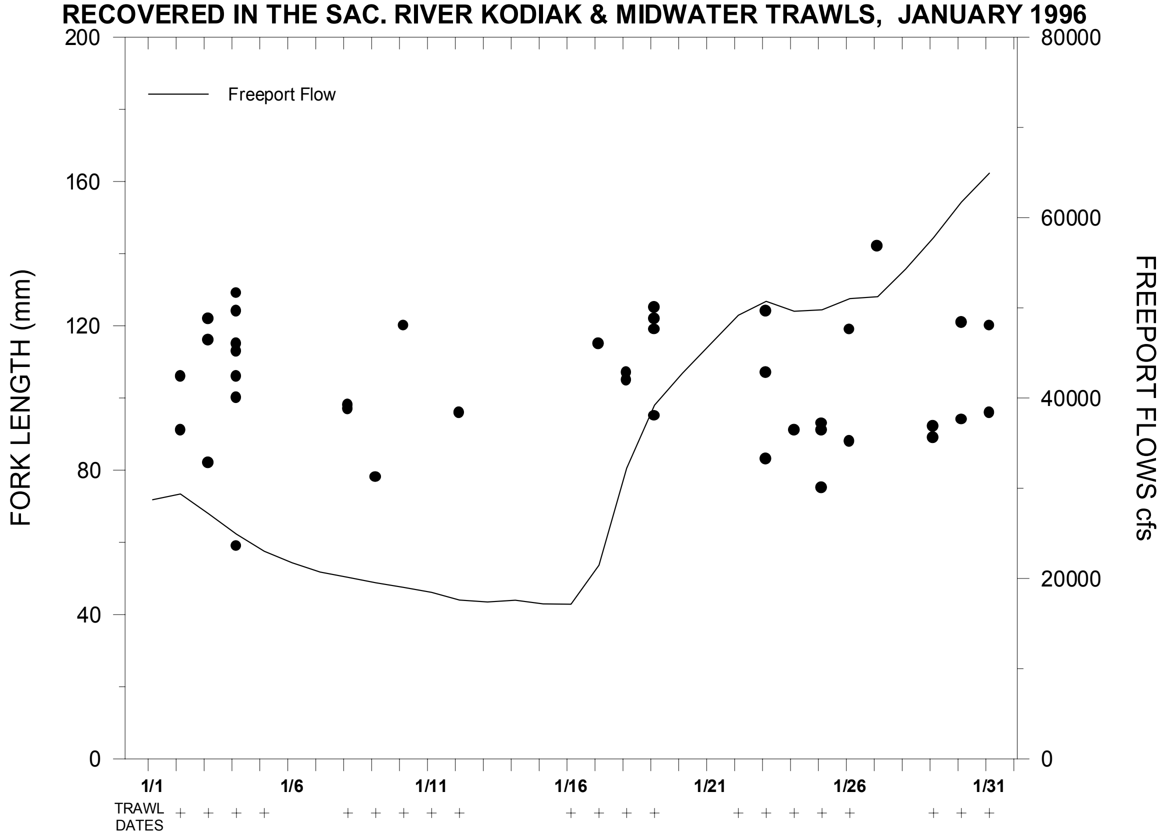


FIGURE 7. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, JANUARY 1996

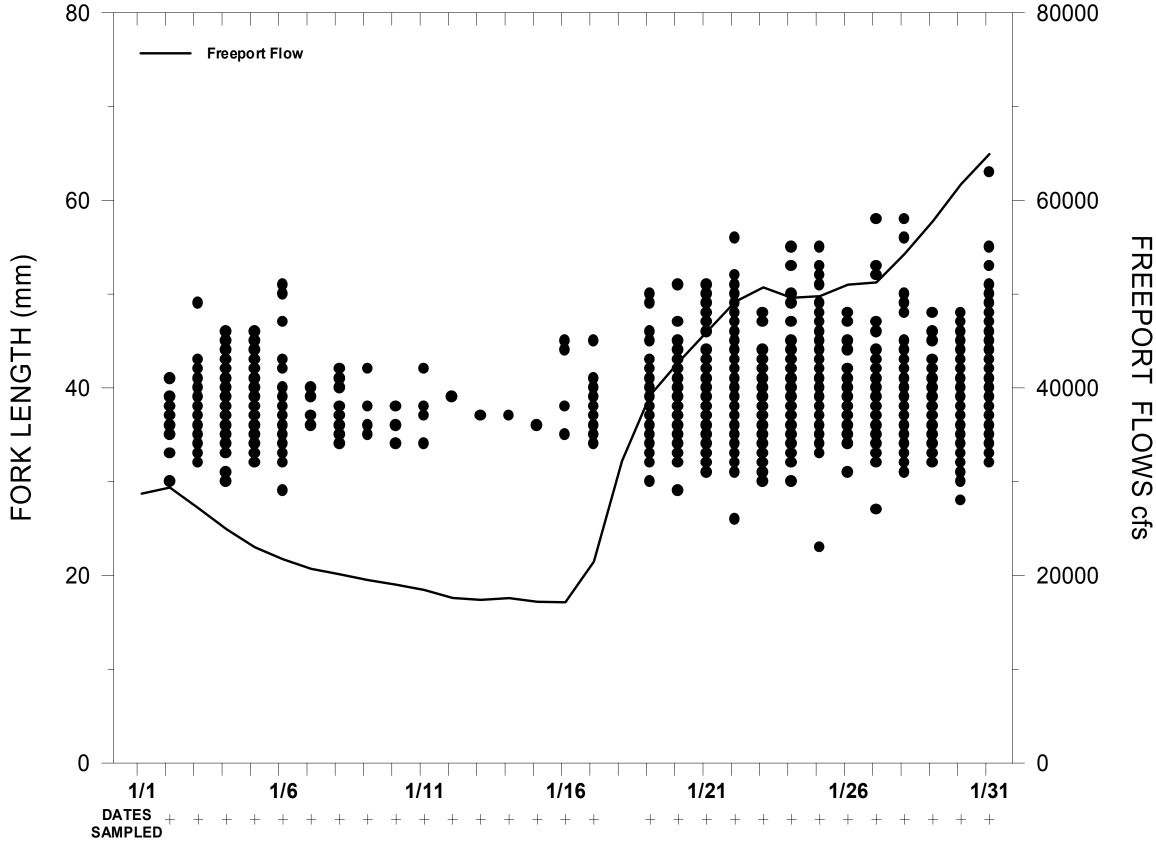


FIGURE 8. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, JANUARY 1996

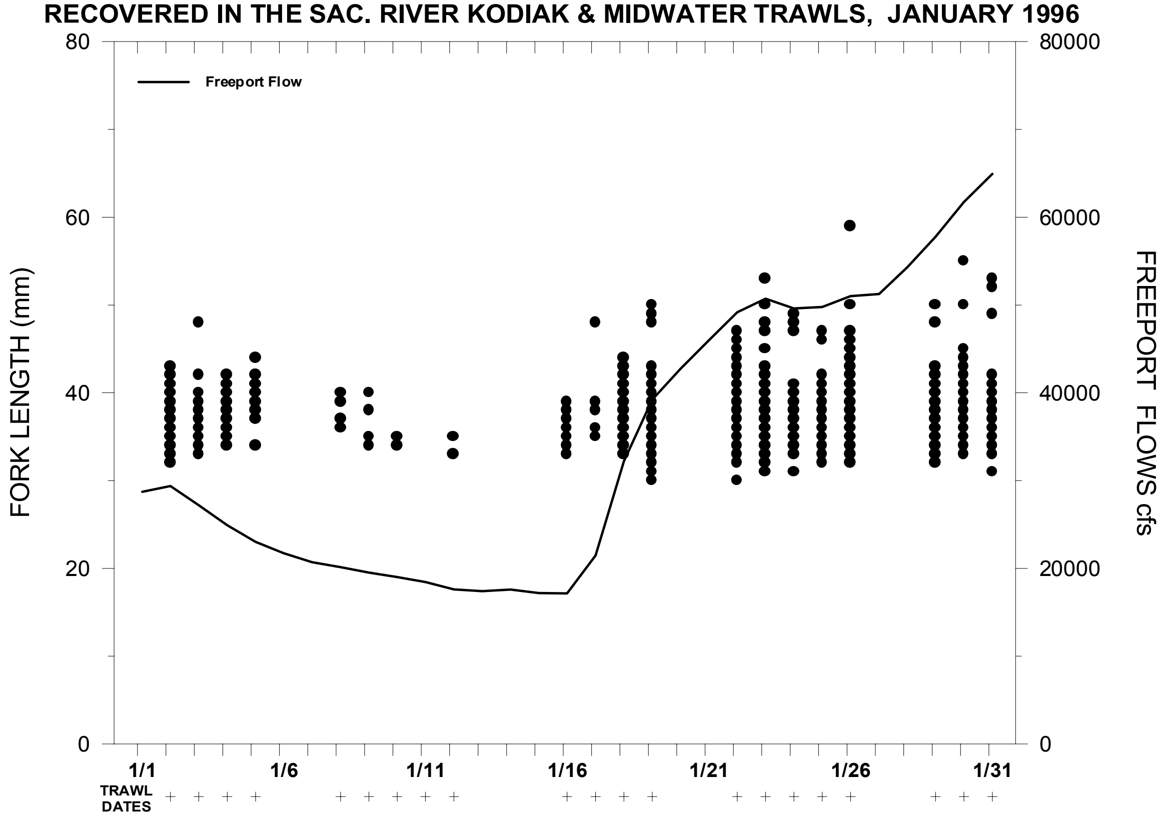


FIGURE 9. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, NOVEMBER 1996

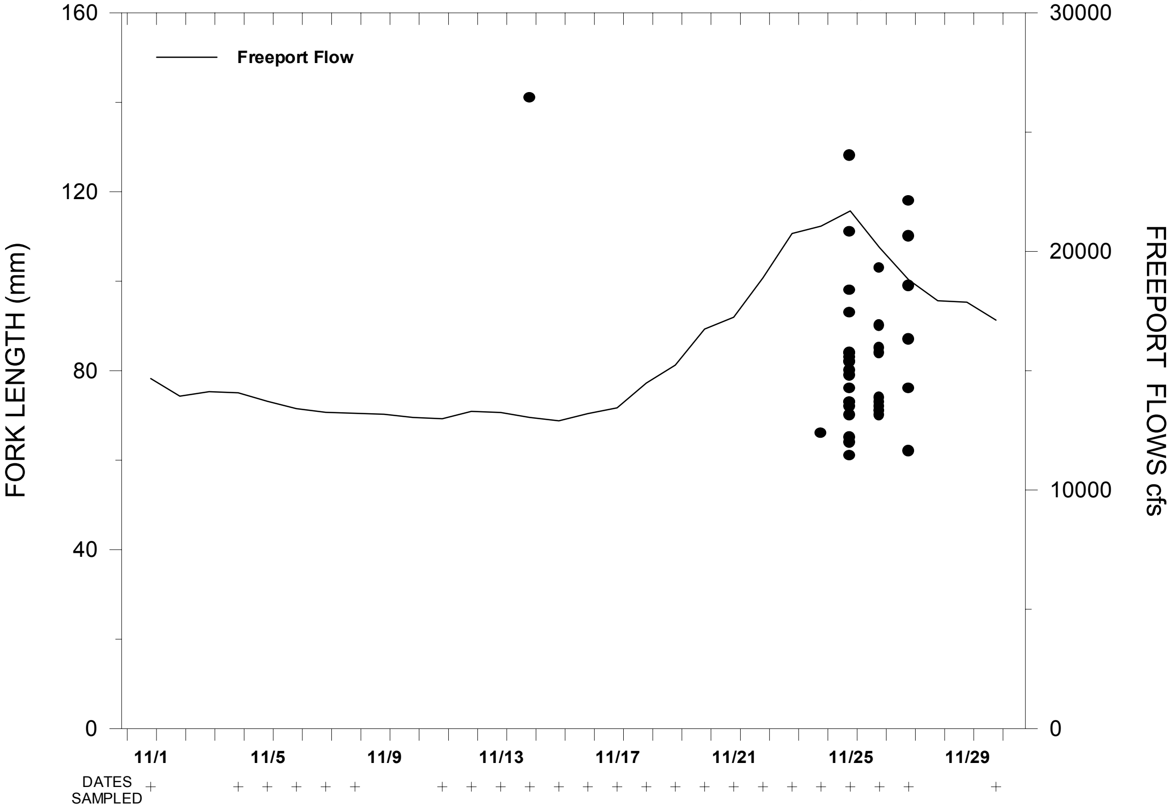


FIGURE 10. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, NOVEMBER 1996

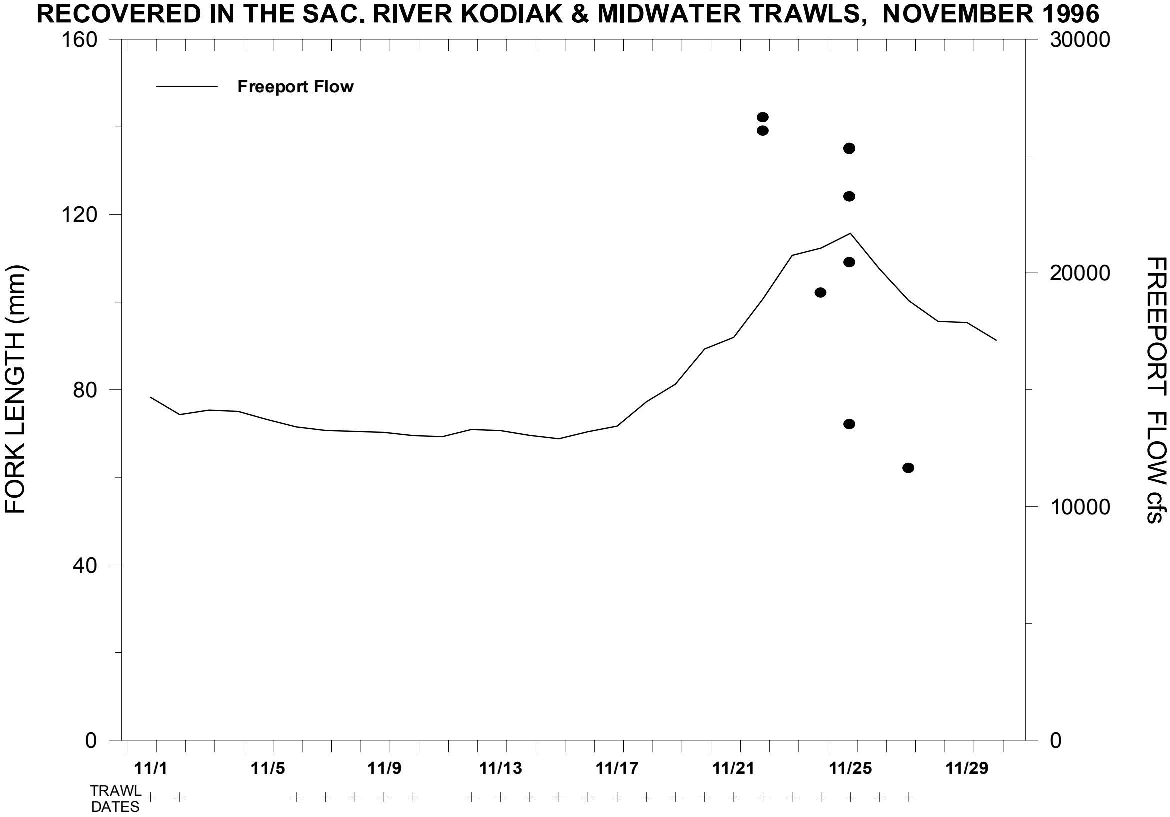


FIGURE 11. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, NOVEMBER 1996

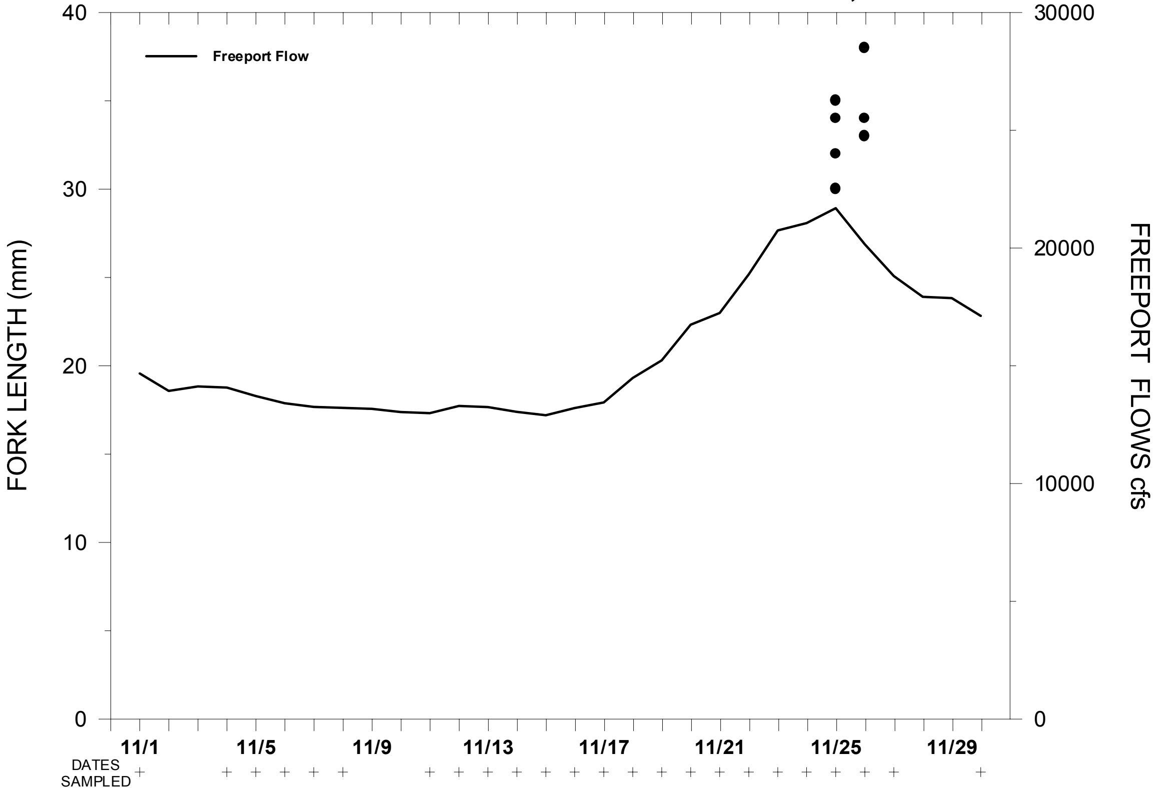


FIGURE 12. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, NOVEMBER 1996

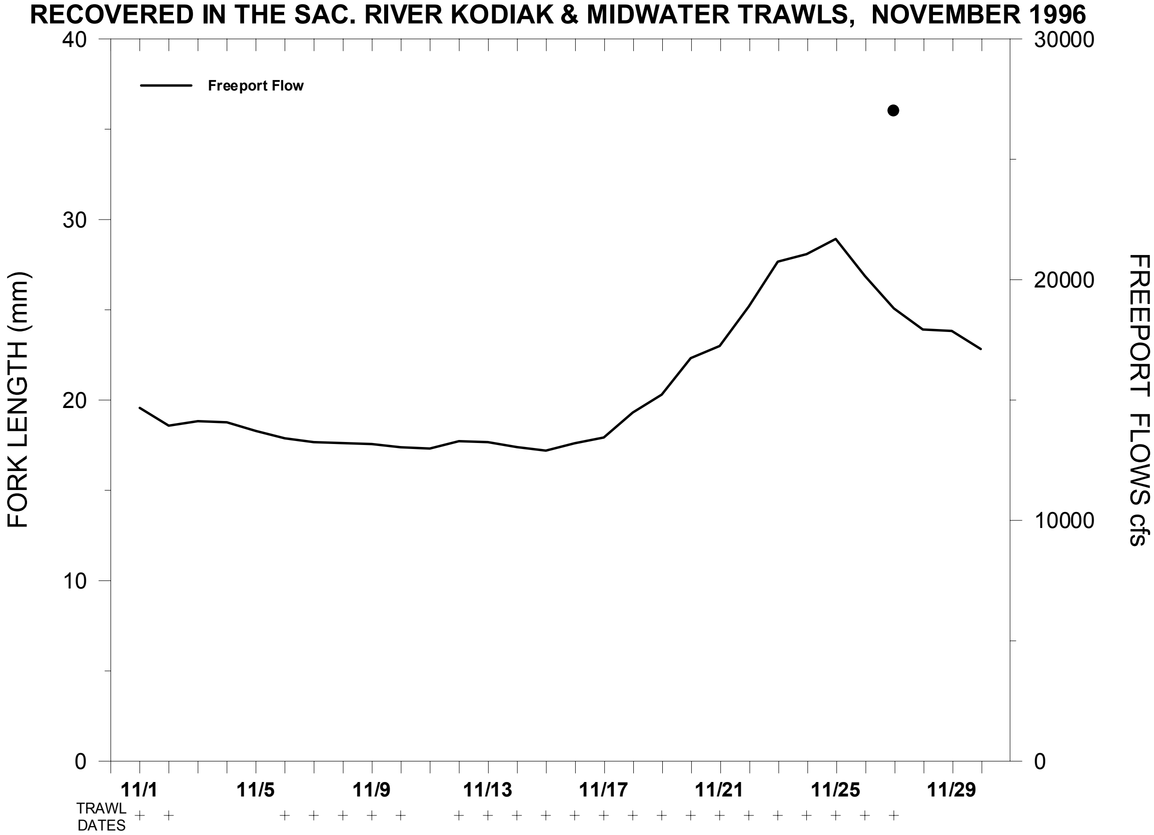


FIGURE 13. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, DECEMBER 1996

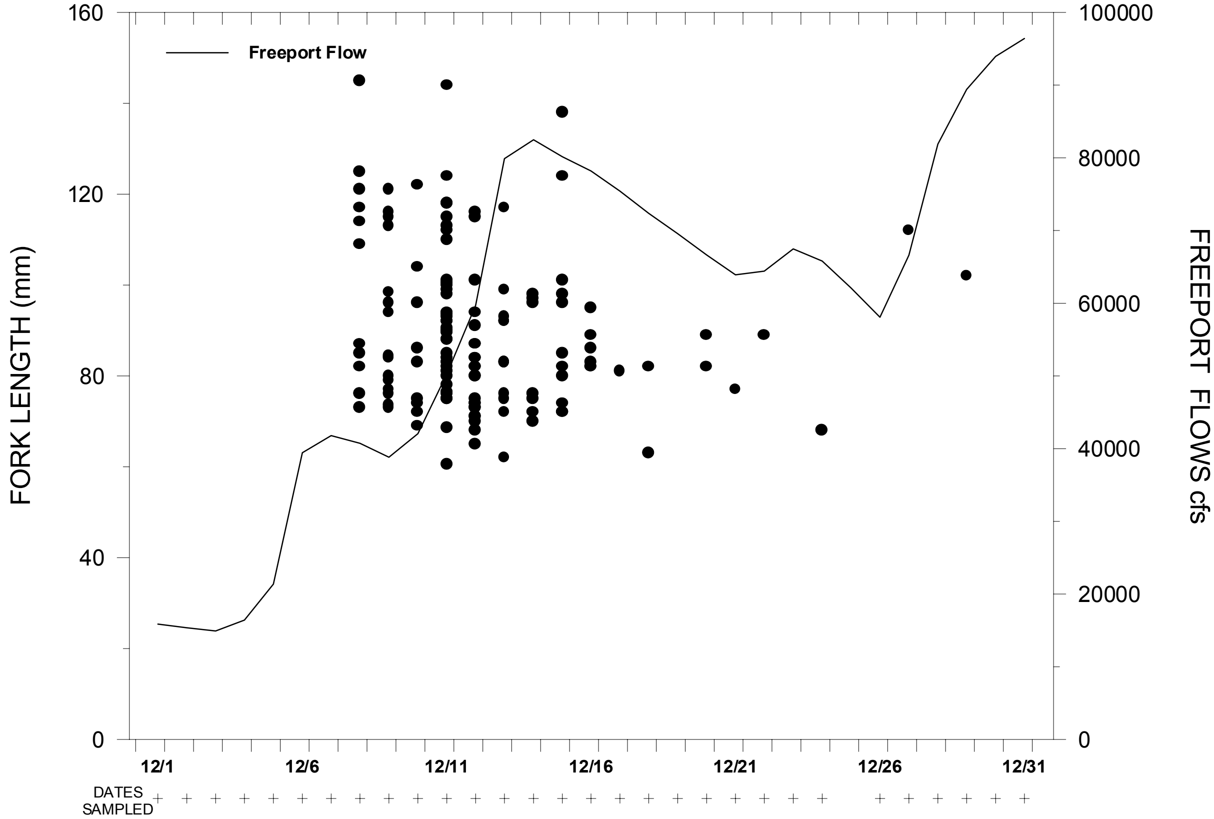


FIGURE 14. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, DECEMBER 1996

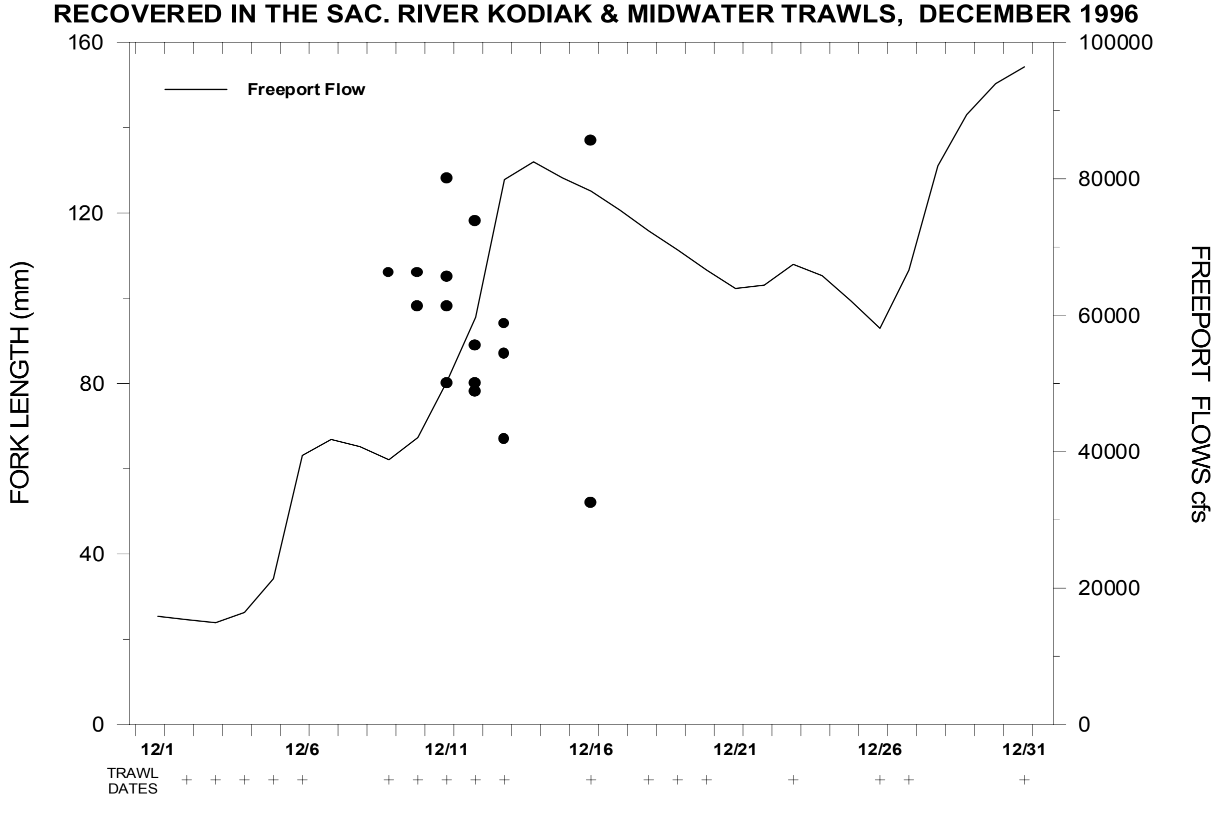


FIGURE 15. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, DECEMBER 1996

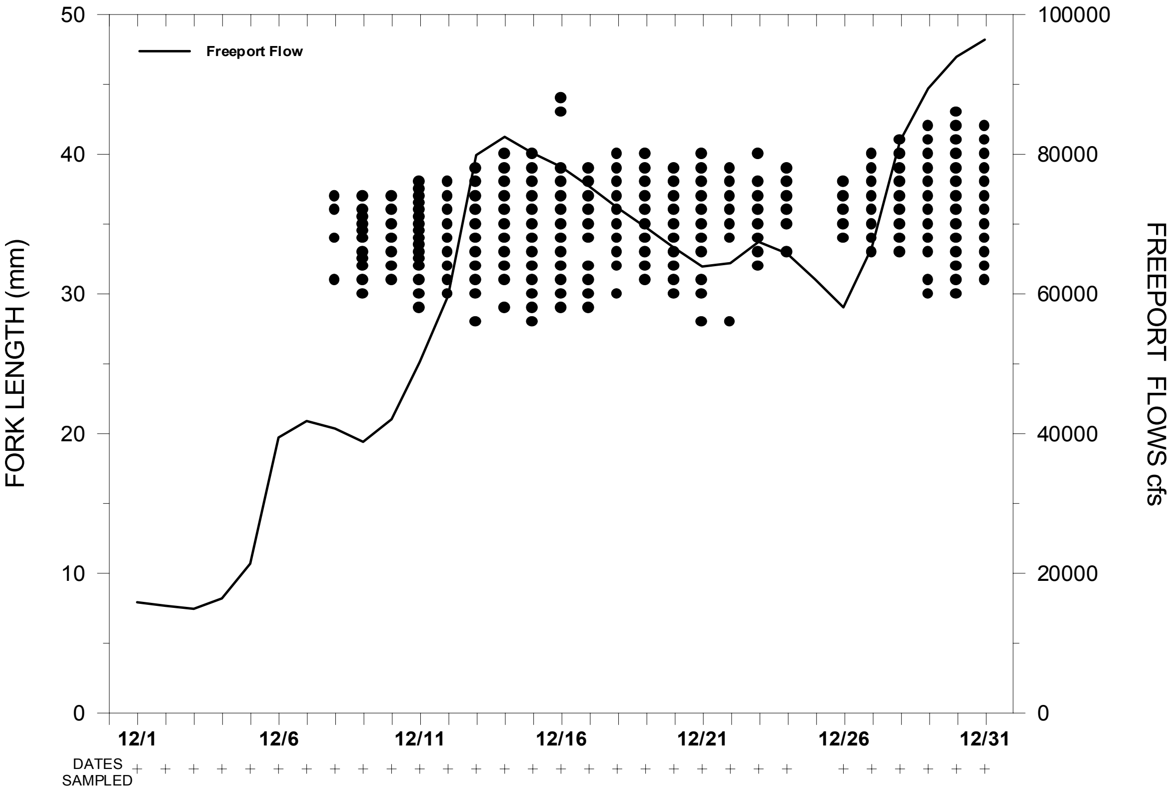


FIGURE 16. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWL, DECEMBER 1996

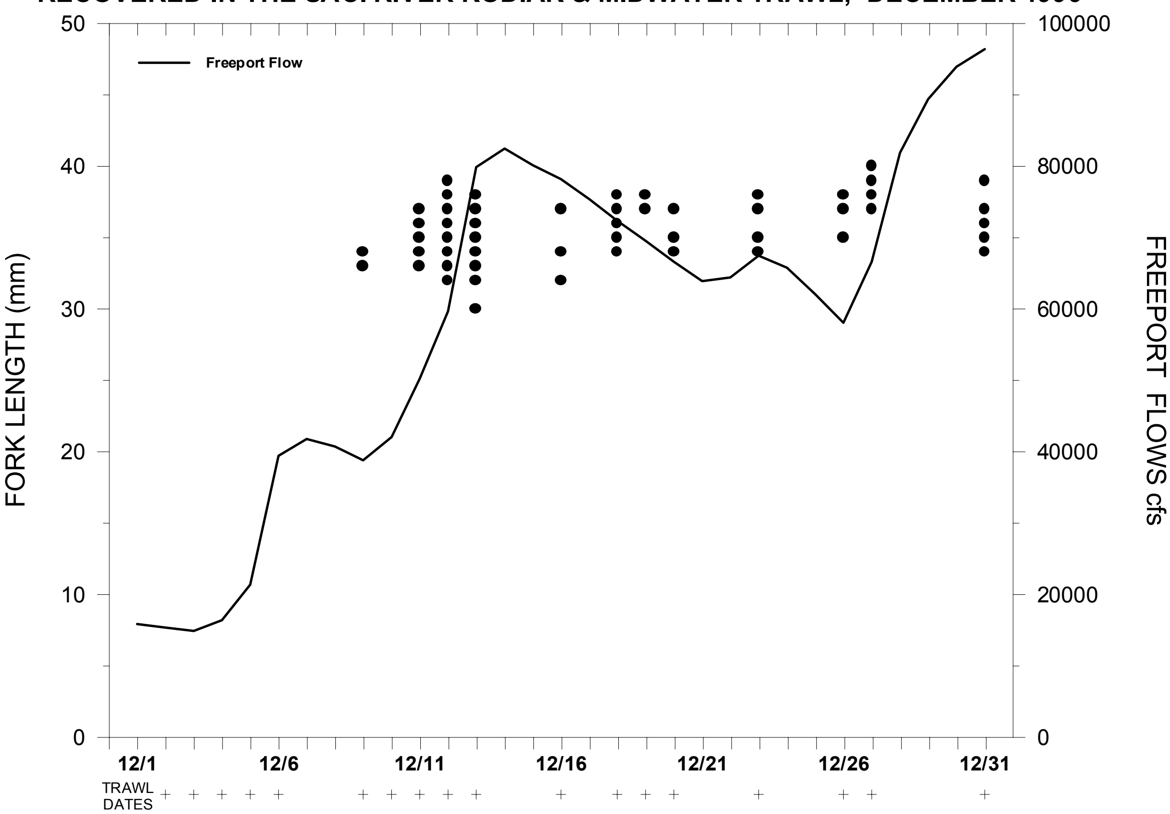


FIGURE 17. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, JANUARY 1997

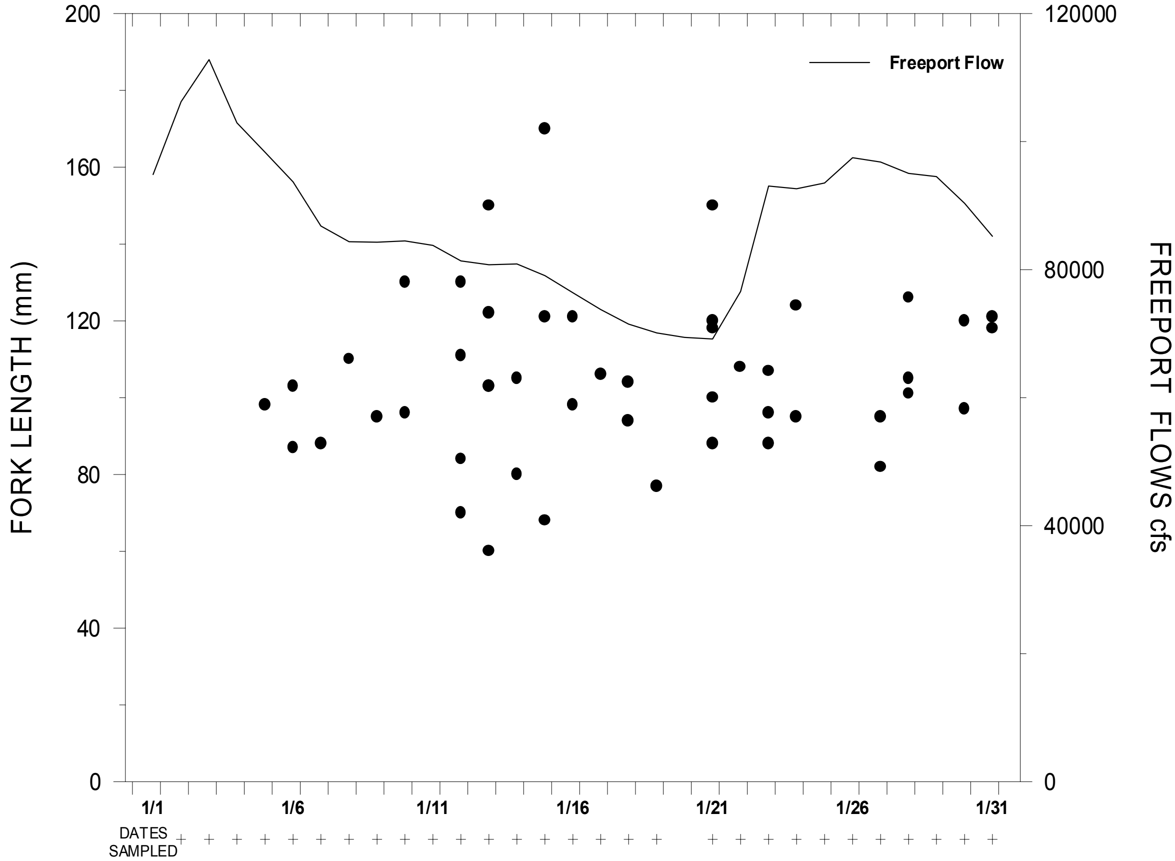


FIGURE 18. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, JANUARY 1997

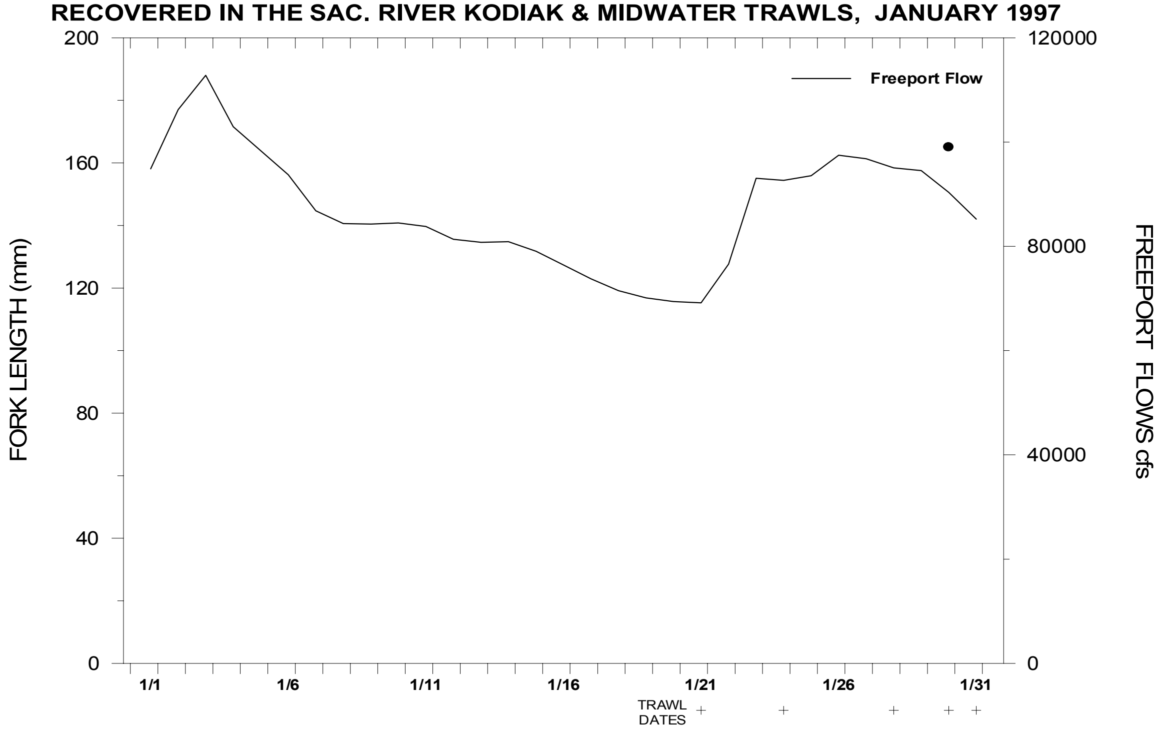


FIGURE 19. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, JANUARY 1997

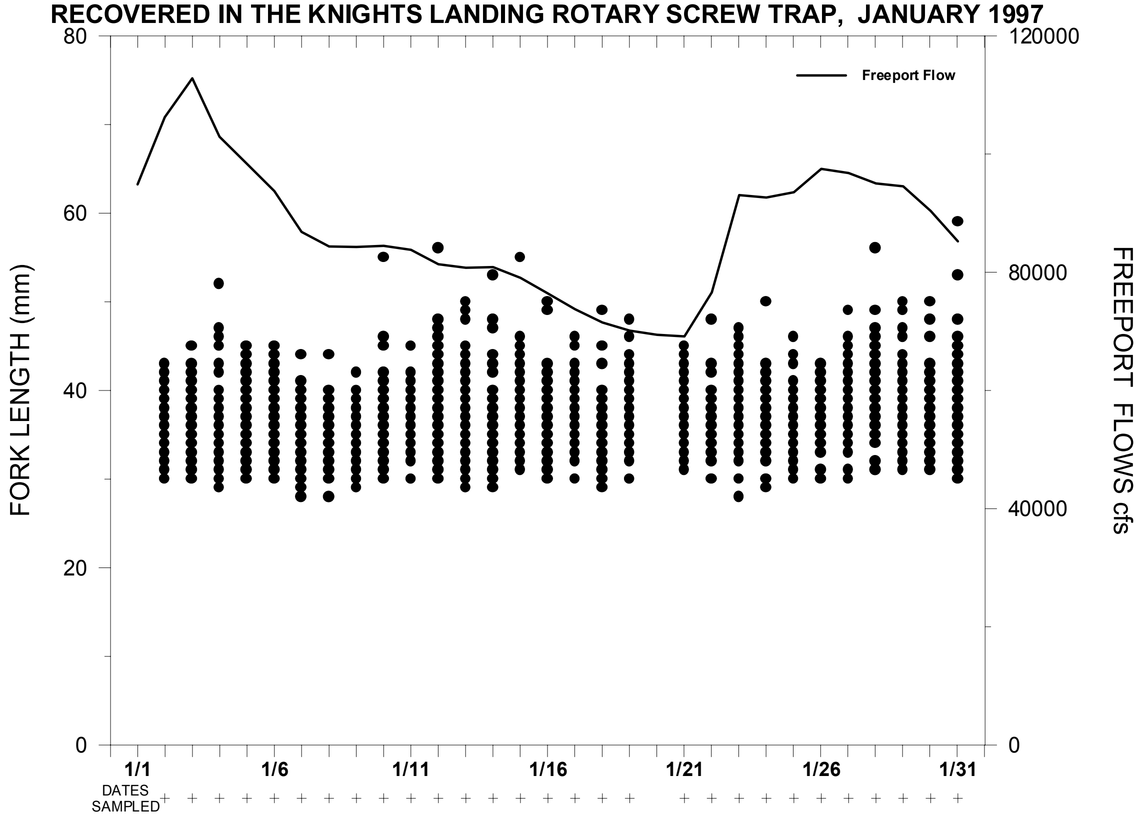


FIGURE 20. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, JANUARY 1997

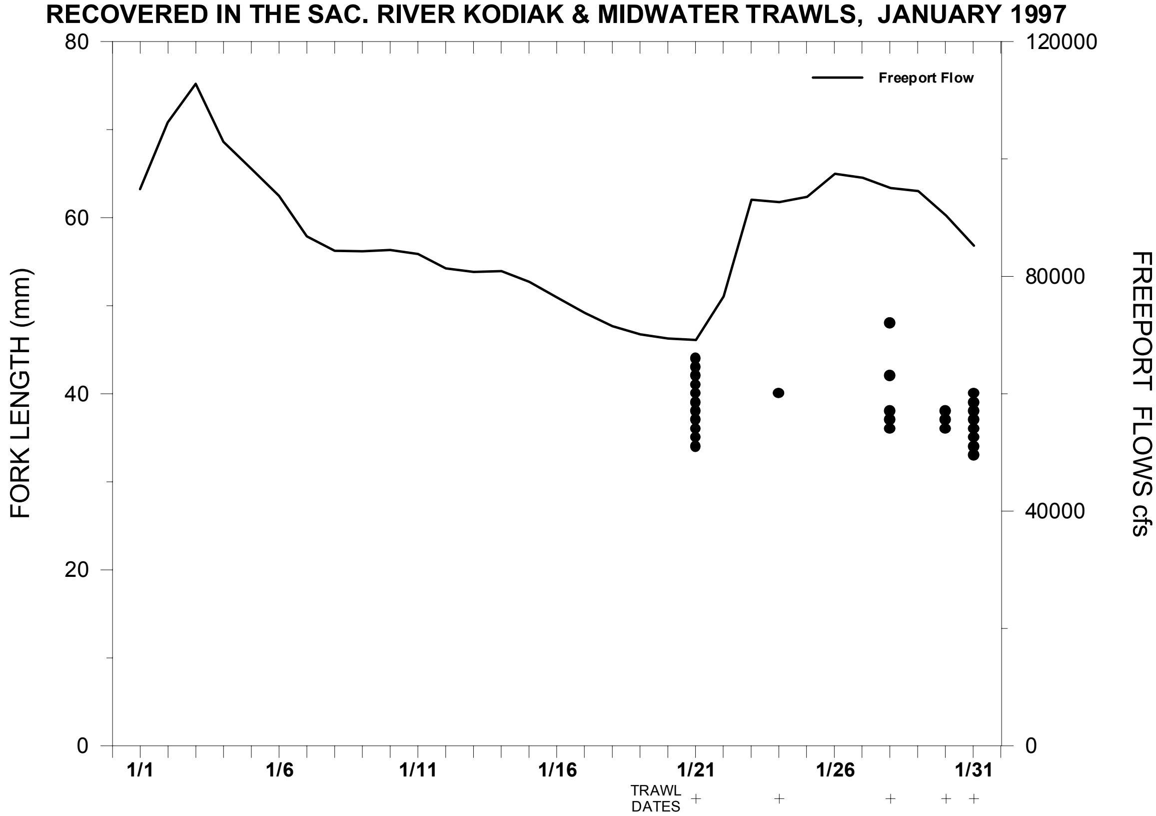


FIGURE 21. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, OCTOBER 1997

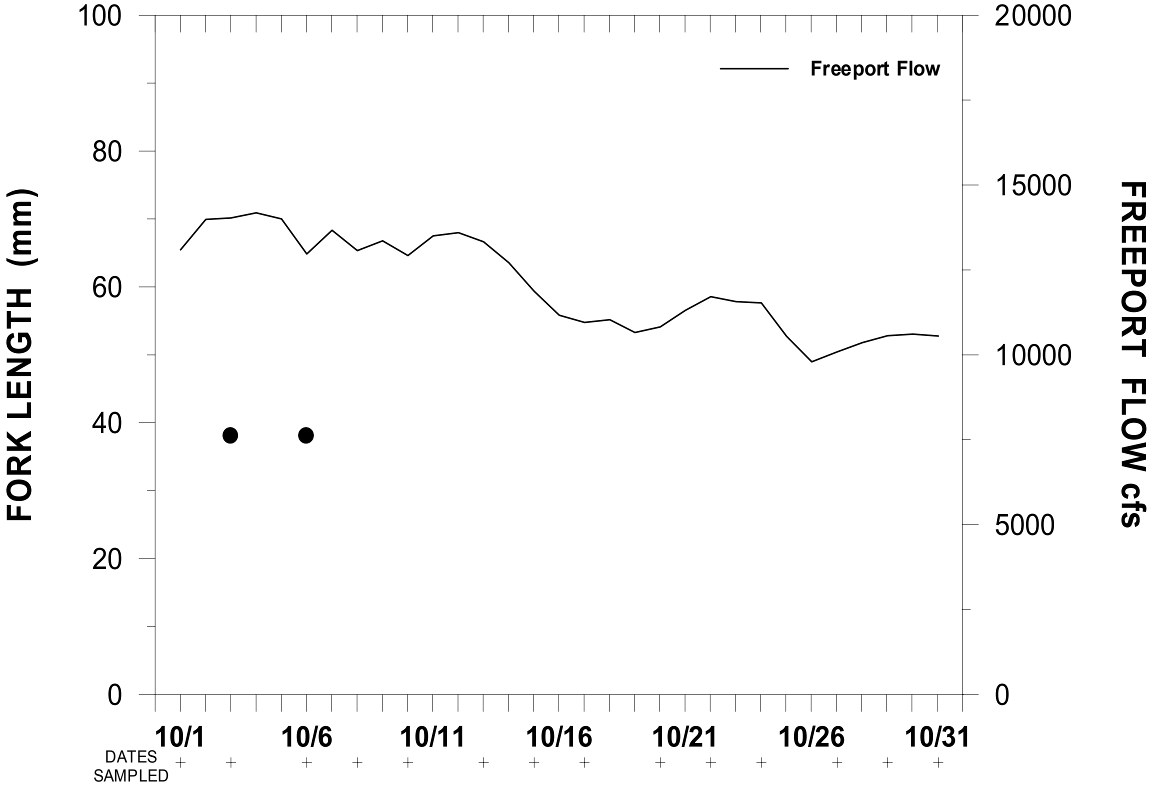


FIGURE 22. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, OCTOBER 1997

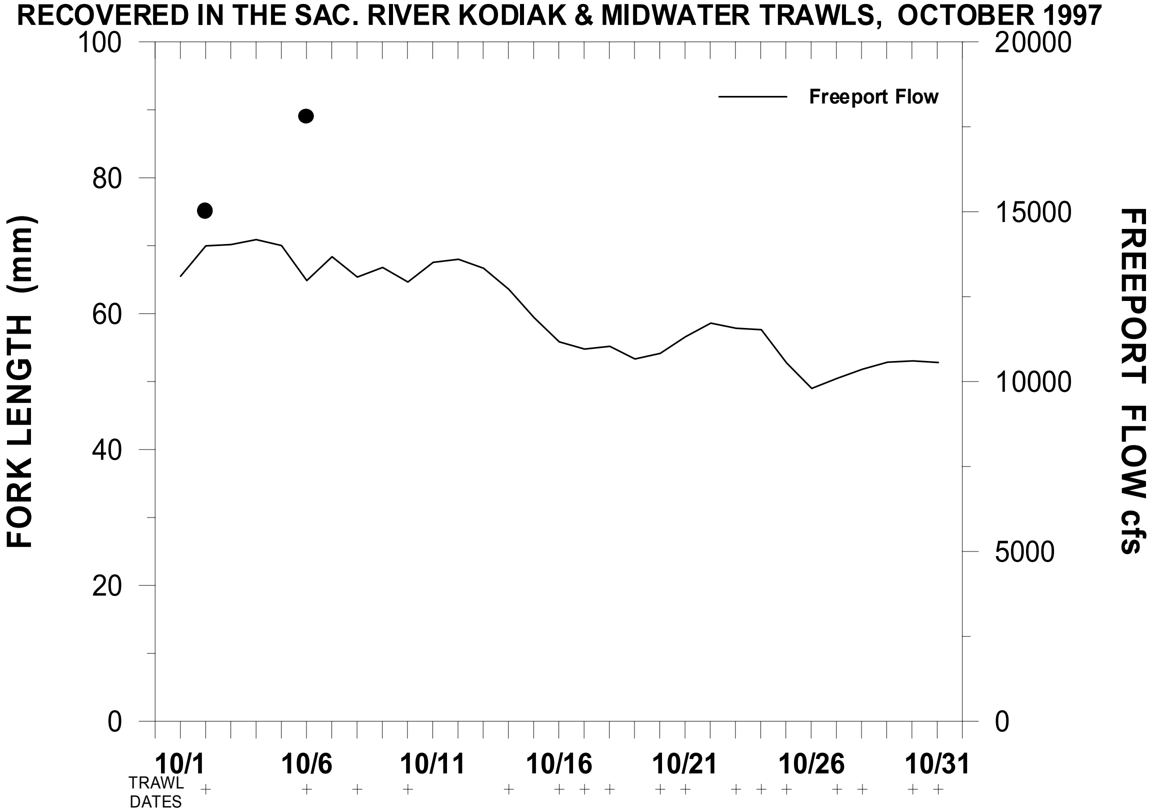


FIGURE 23. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, NOVEMBER 1997

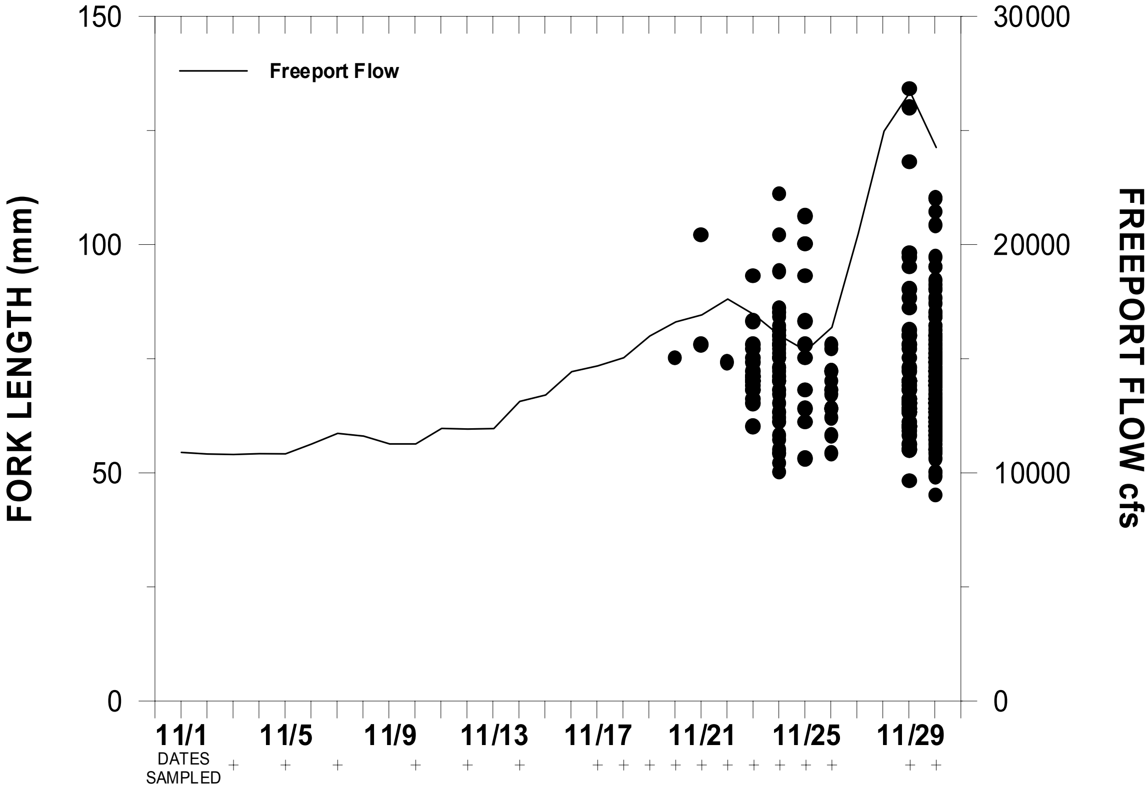


FIGURE 24. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWL, NOVEMBER 1997

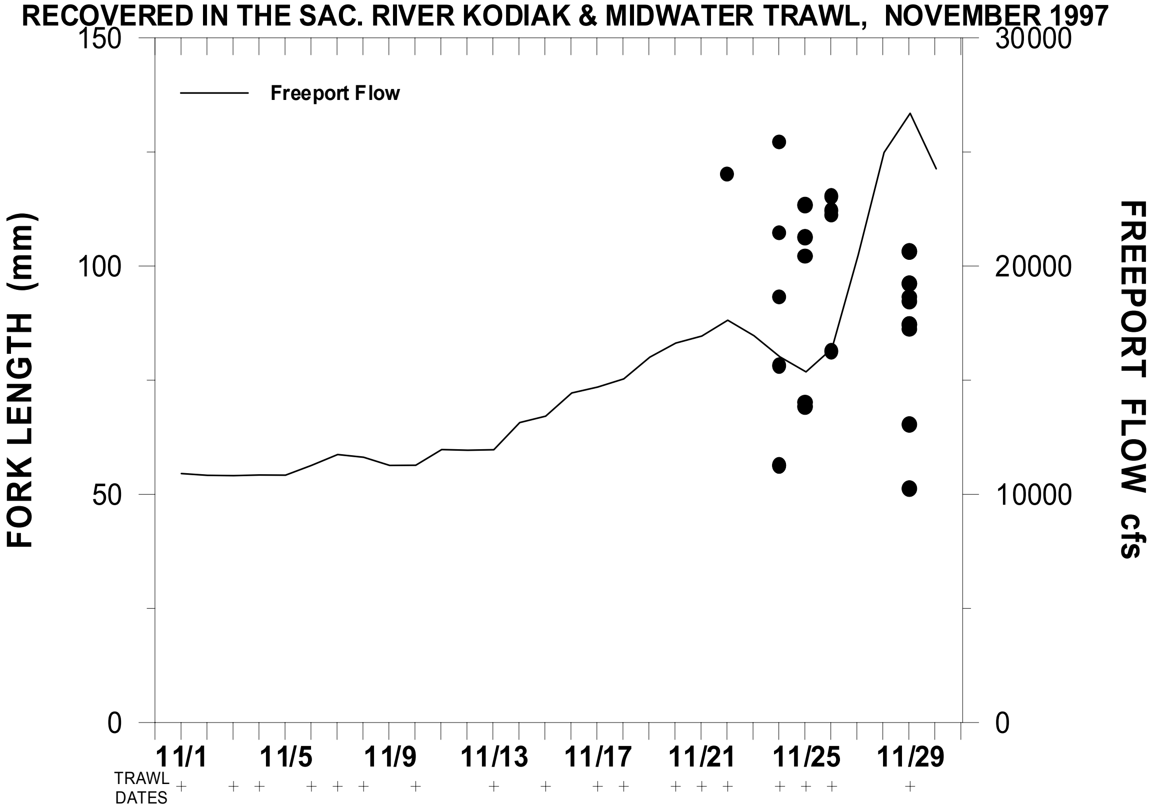


FIGURE 25. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, NOVEMBER 1997

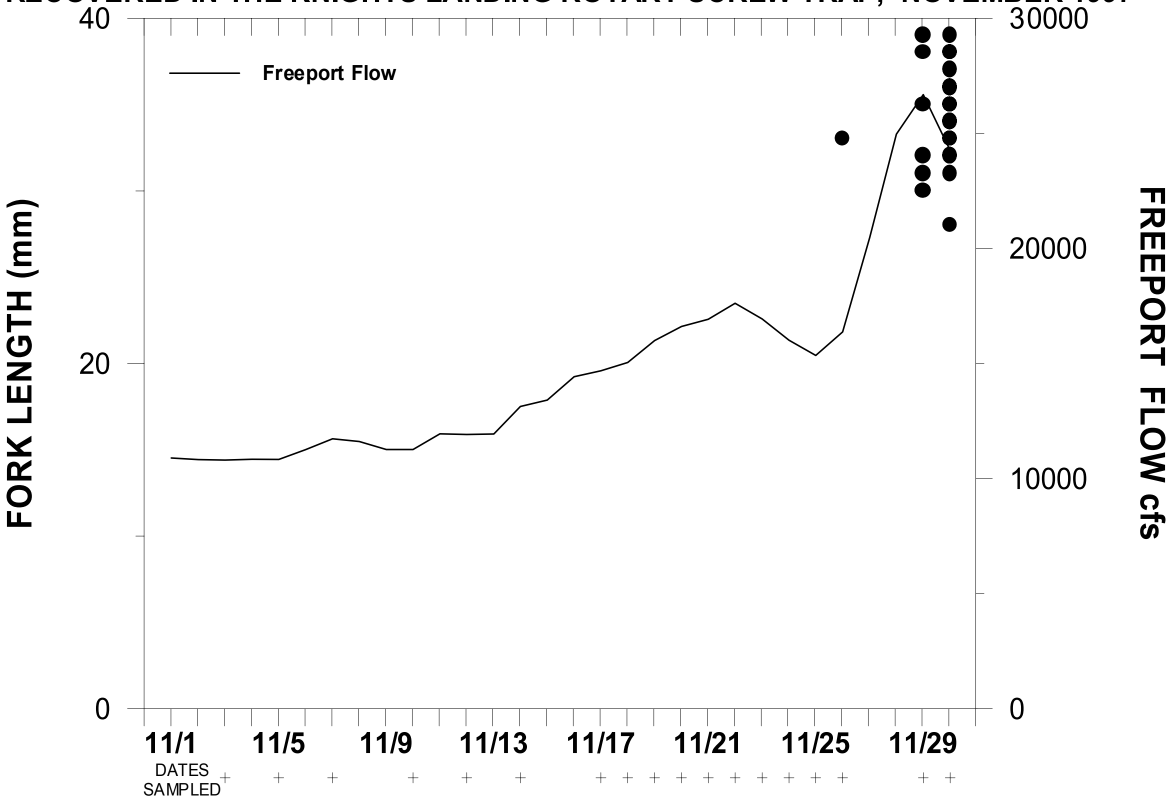


FIGURE 26. CHINOOK BELOW THE MINIMUN WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, NOVEMBER 1997

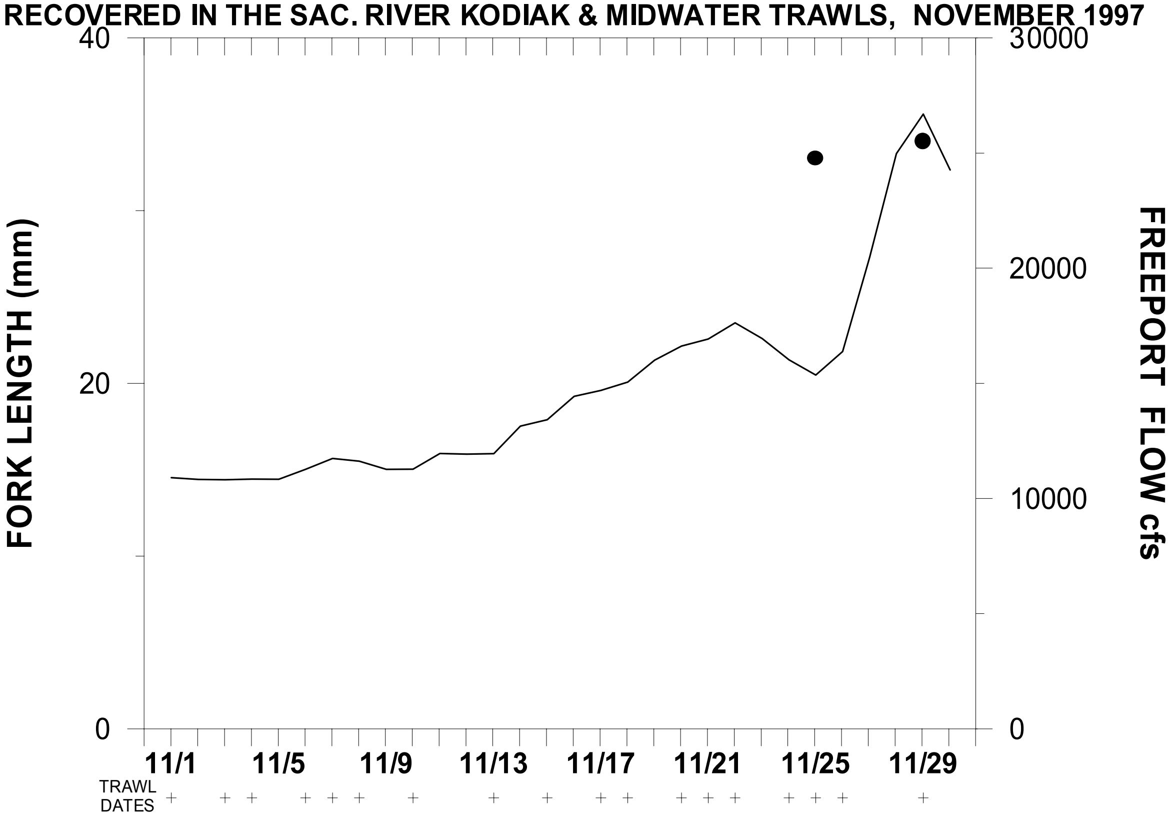


FIGURE 27. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, DECEMBER 1997

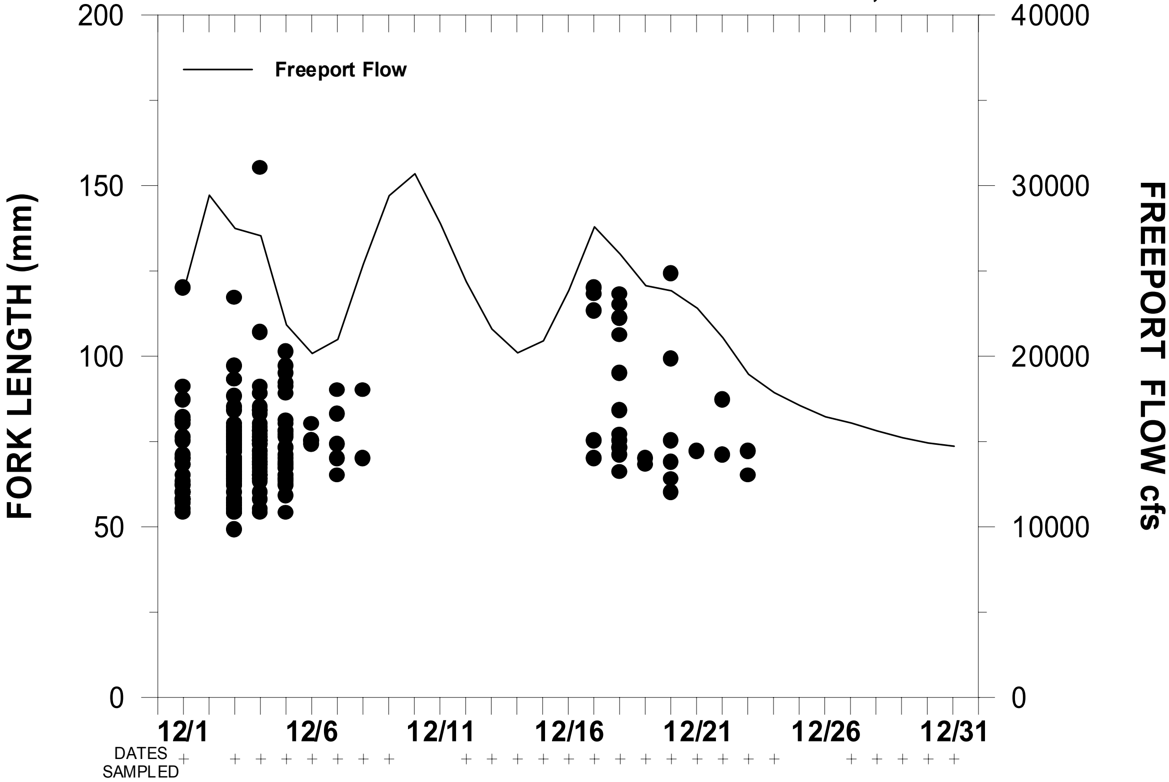


FIGURE 28. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, DECEMBER 1997

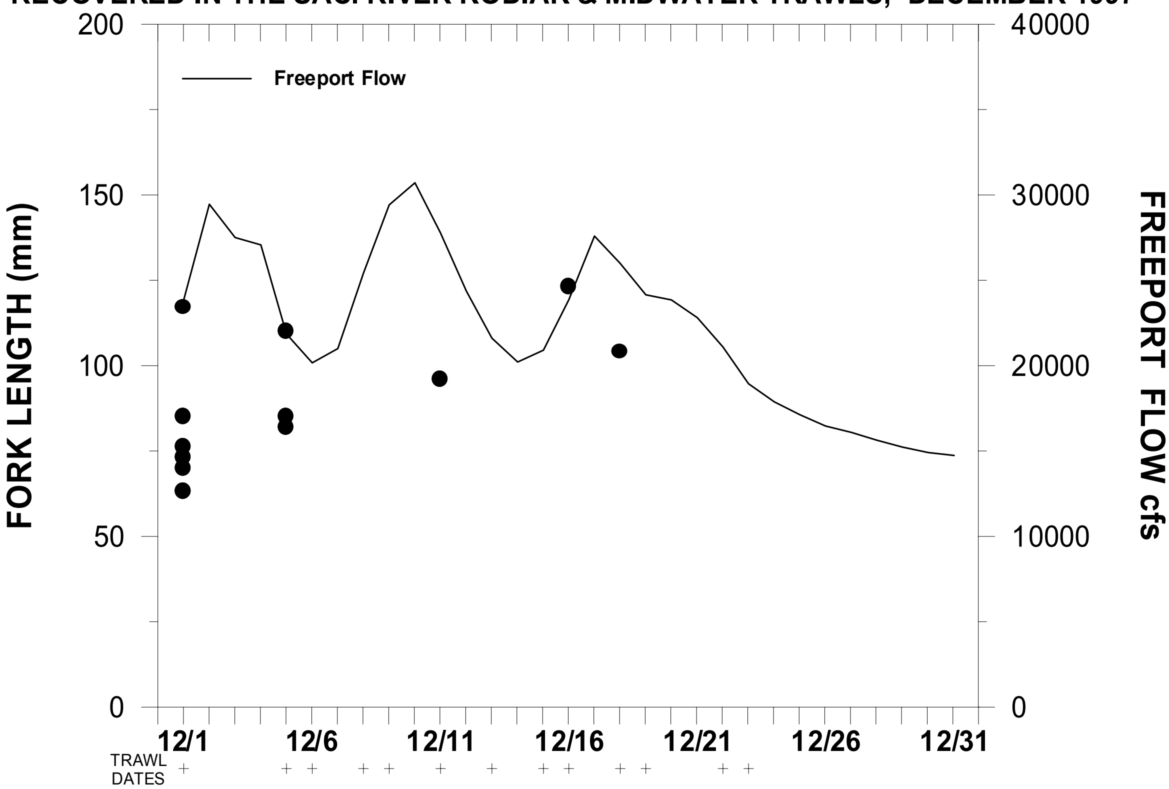


FIGURE 29. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, DECEMBER 1997

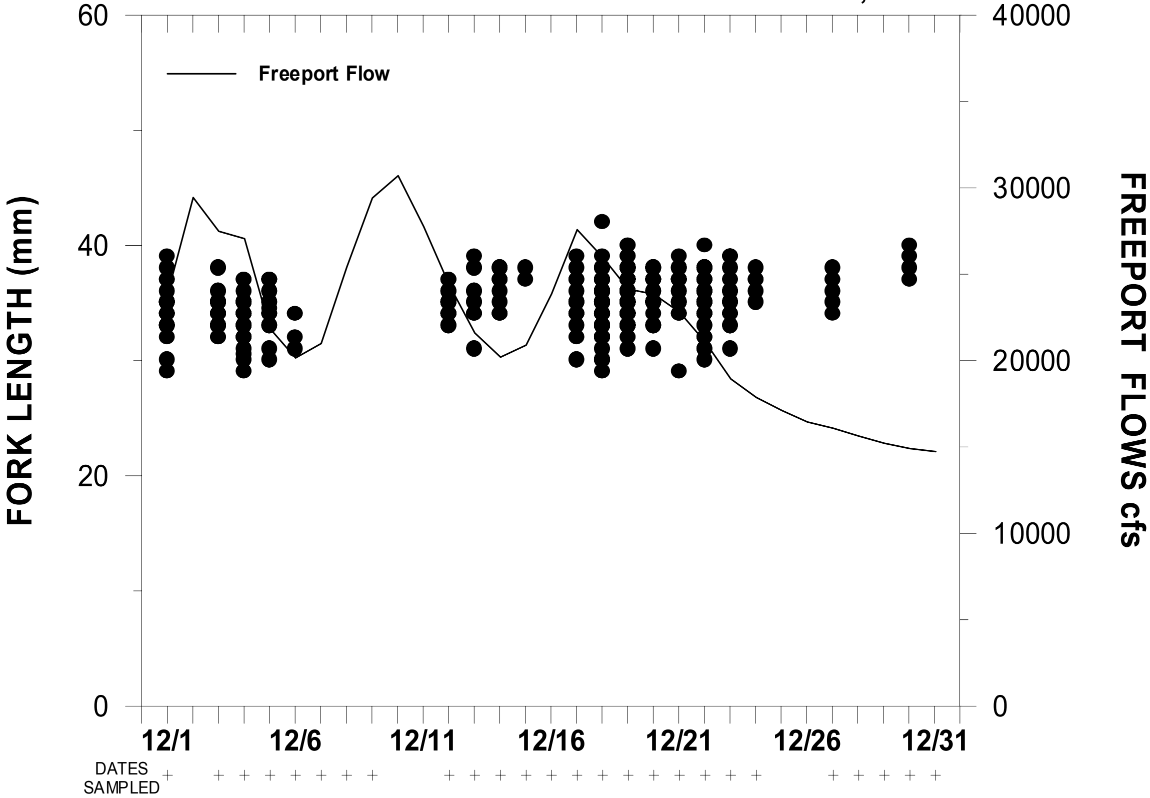


FIGURE 30. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWL, DECEMBER 1997

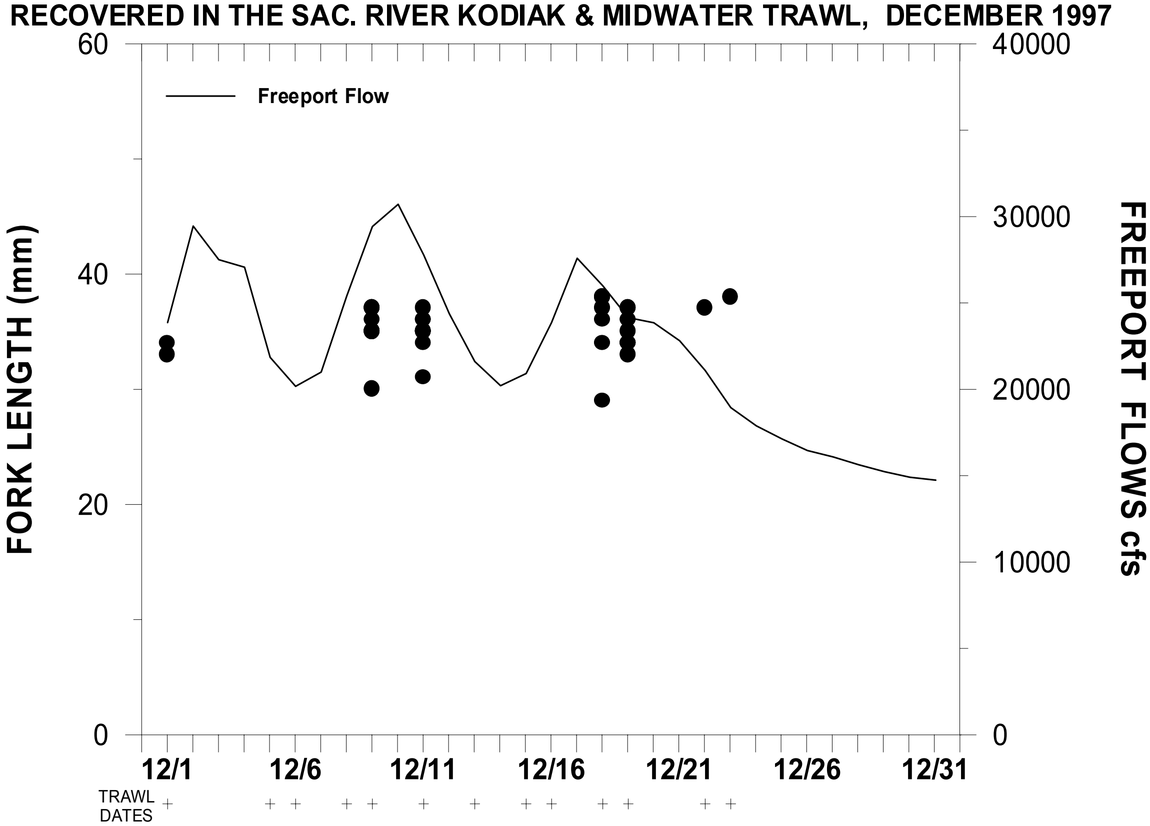


FIGURE 31. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, JANUARY 1998

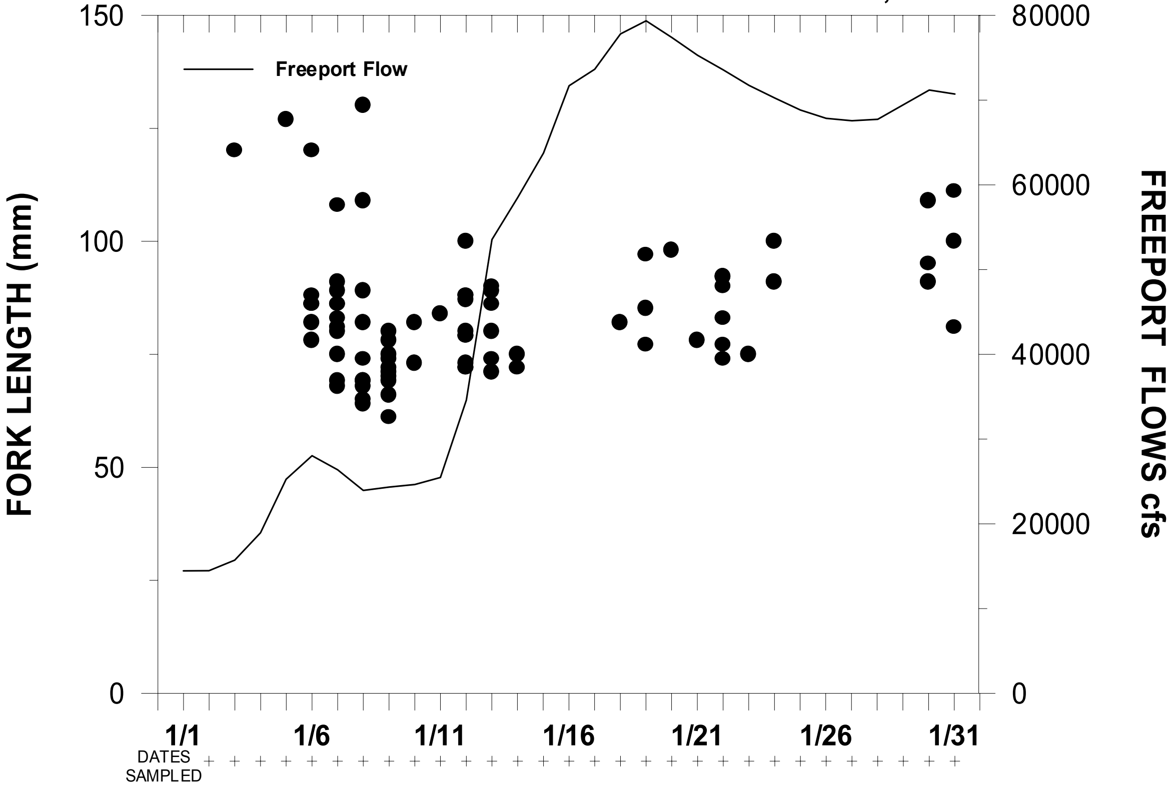


FIGURE 32. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, JANUARY 1998

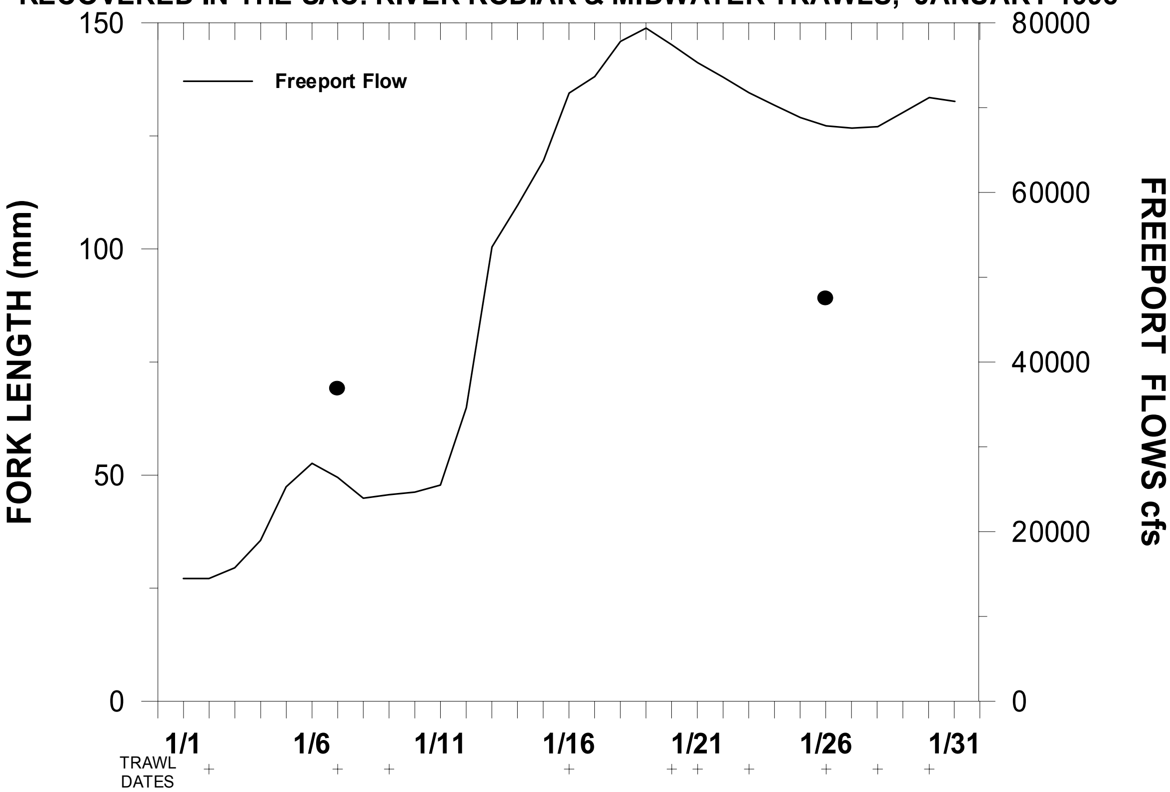


FIGURE 33. CHINOOK BELOW THE MINIMUM WINTER RUN LENGHT LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, JANUARY 1998

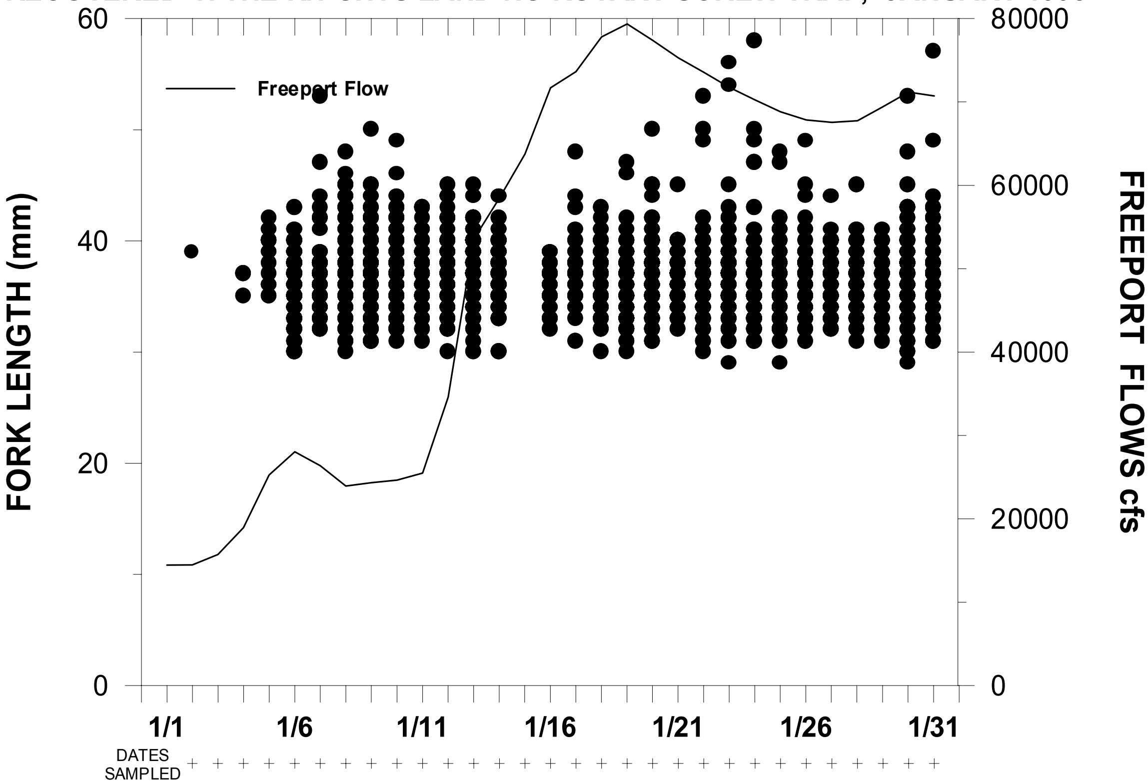


FIGURE 34. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, JANUARY 1998

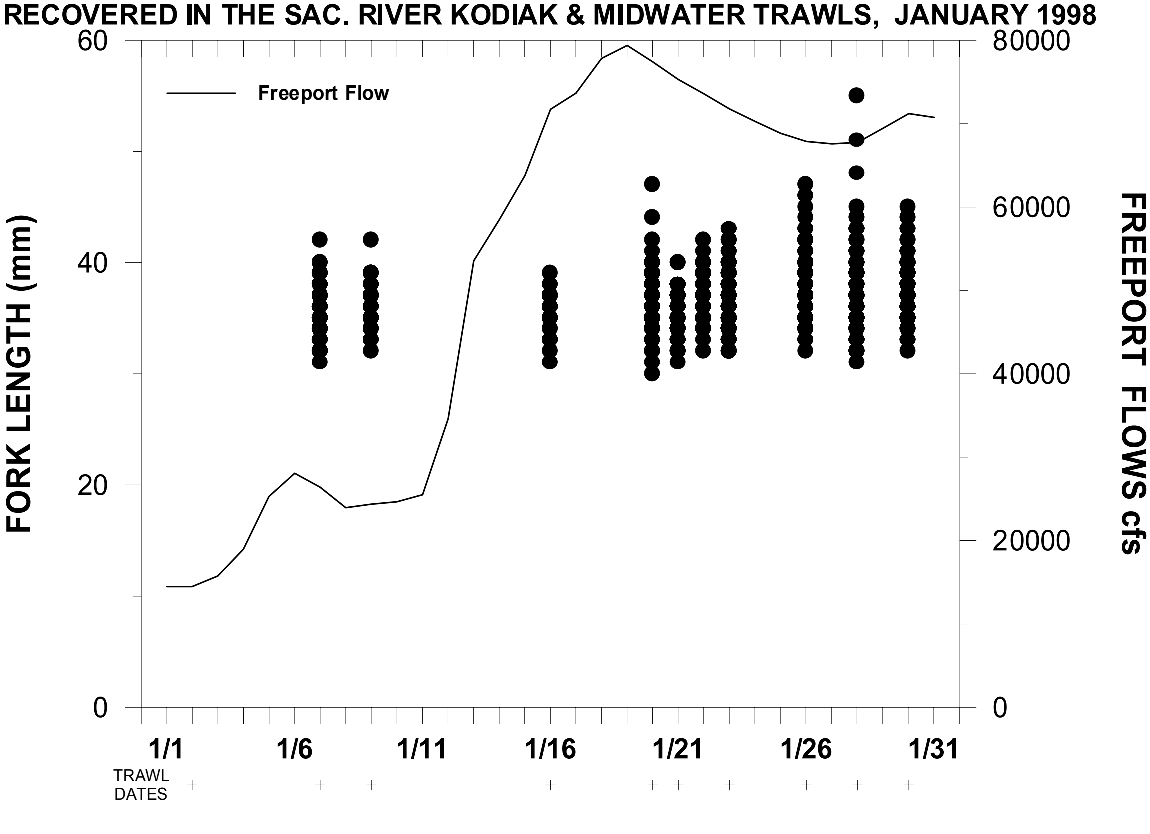


FIGURE 35. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, OCTOBER 1998

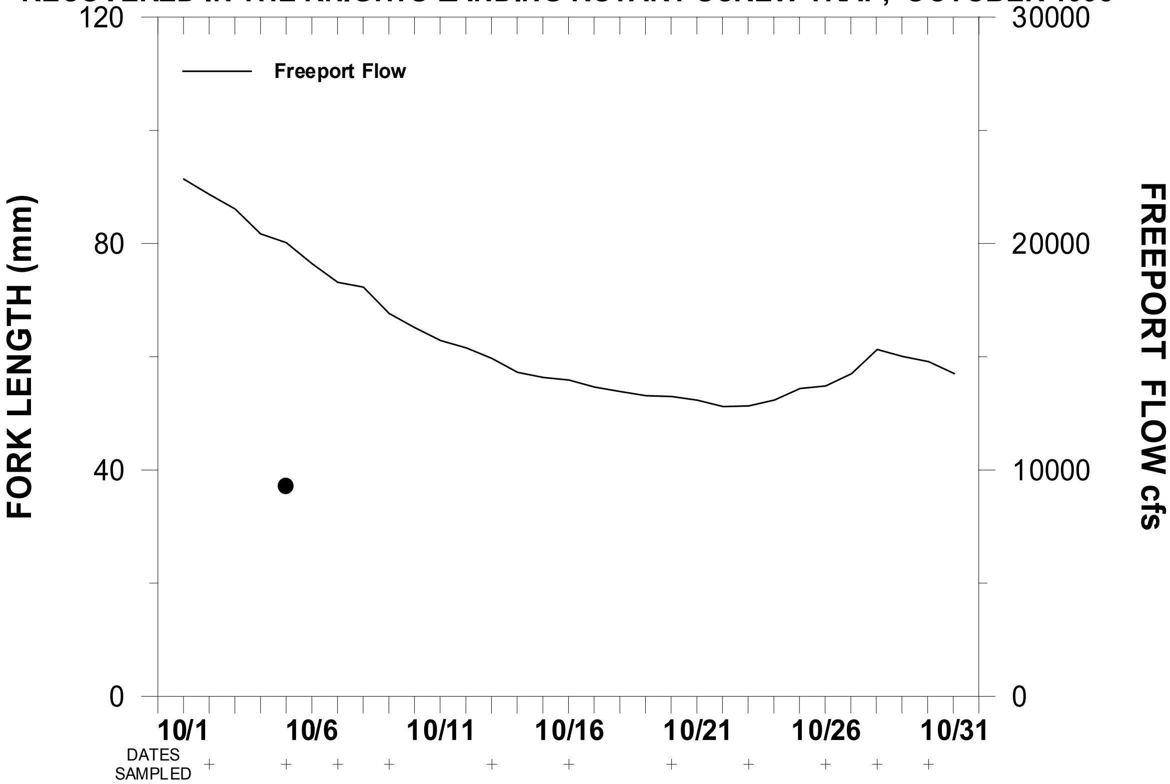


FIGURE 36. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, OCTOBER 1998

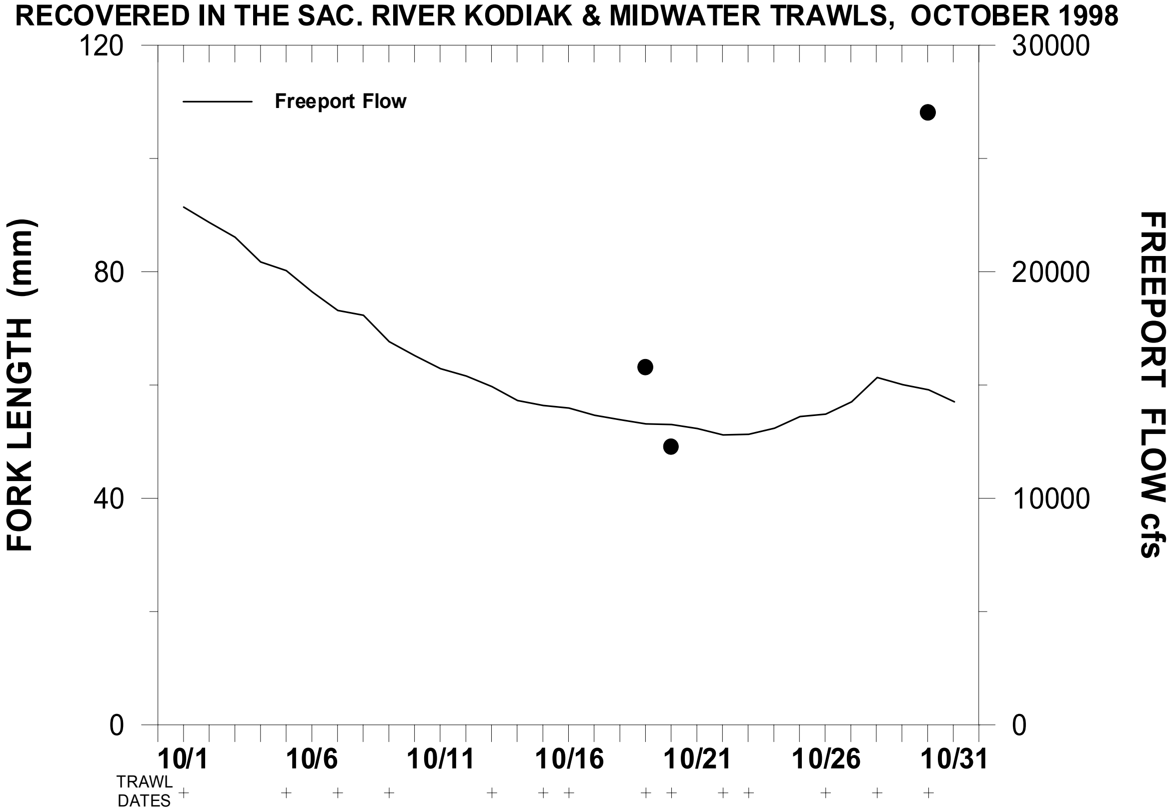


FIGURE 37. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, NOVEMBER 1998

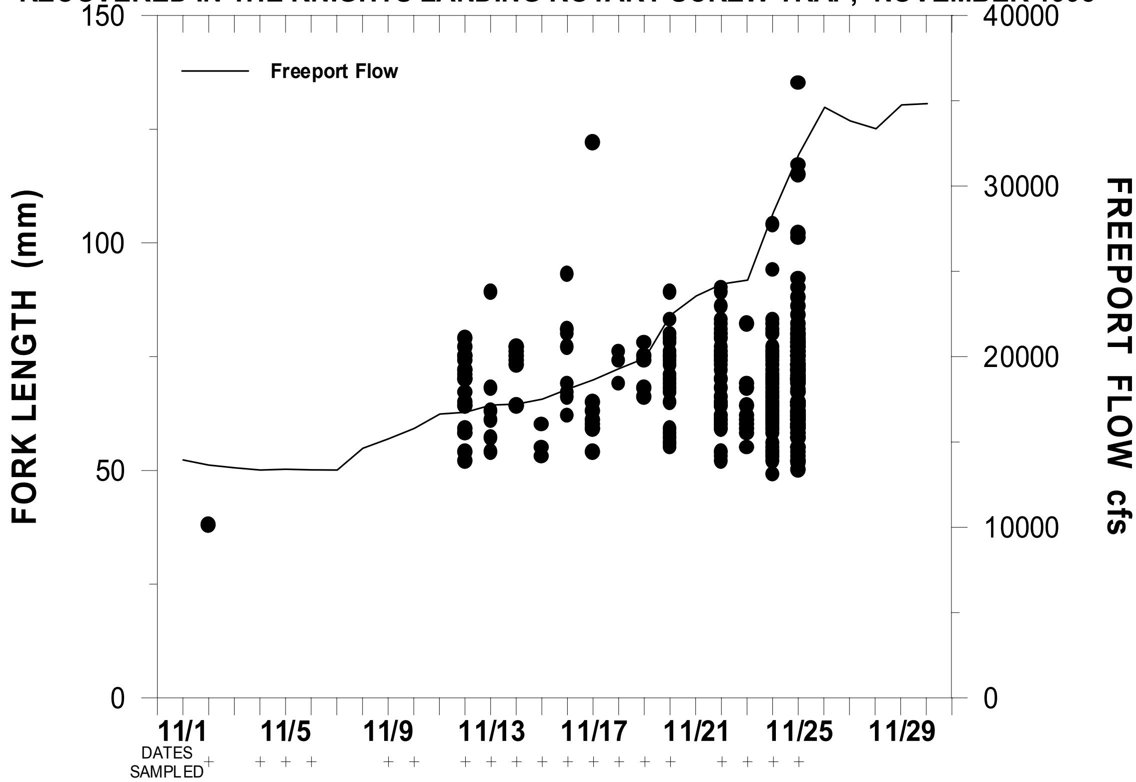


FIGURE 38. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, NOVEMBER 1998

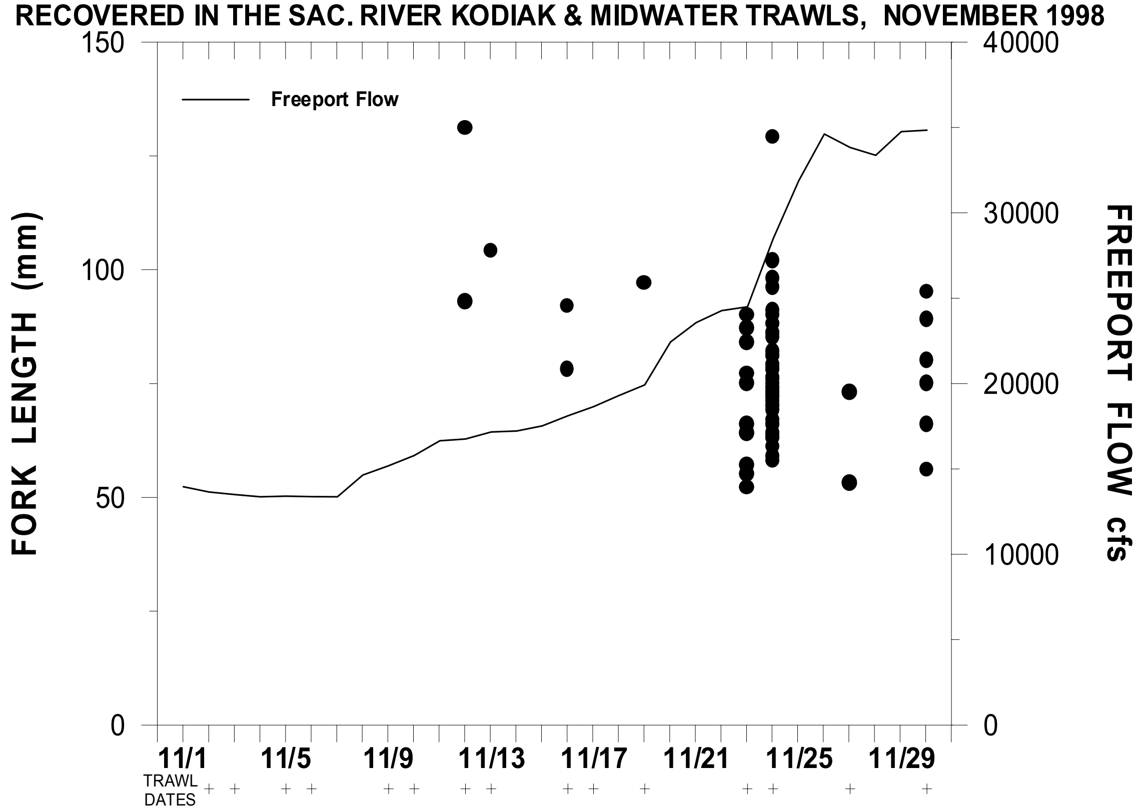


FIGURE 39. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, NOVEMBER 1998

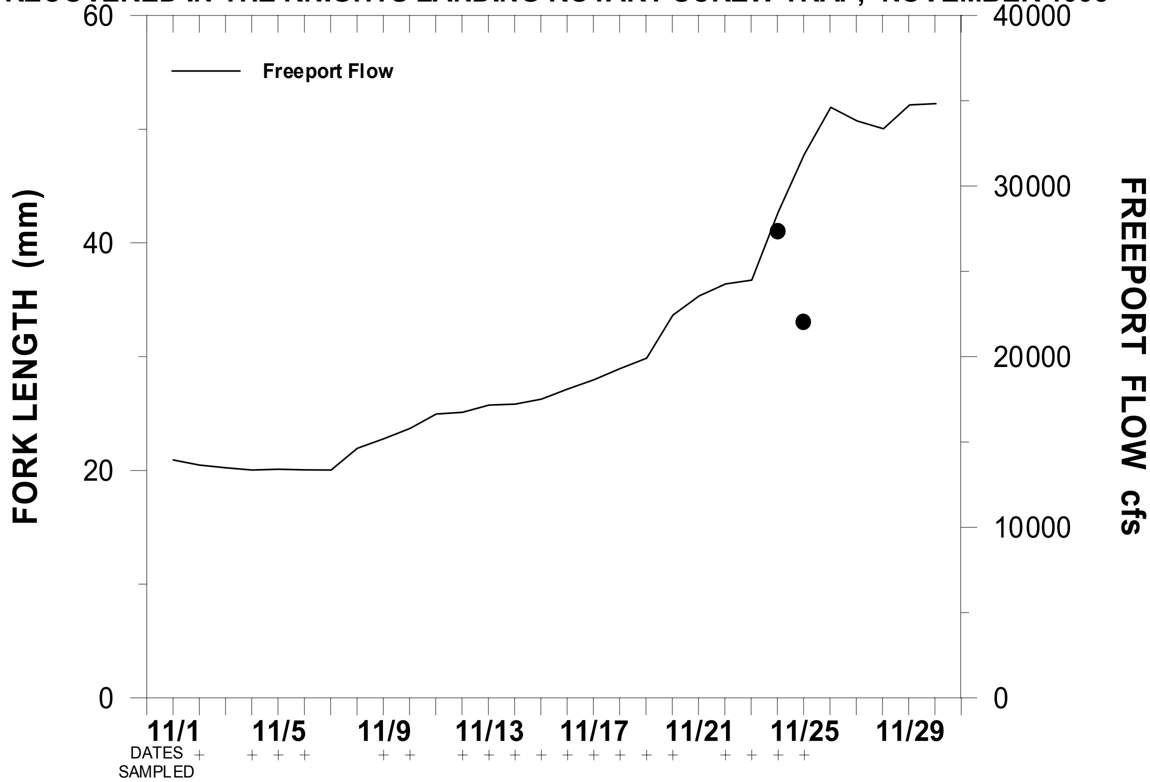


FIGURE 40. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWLS, NOVEMBER 1998

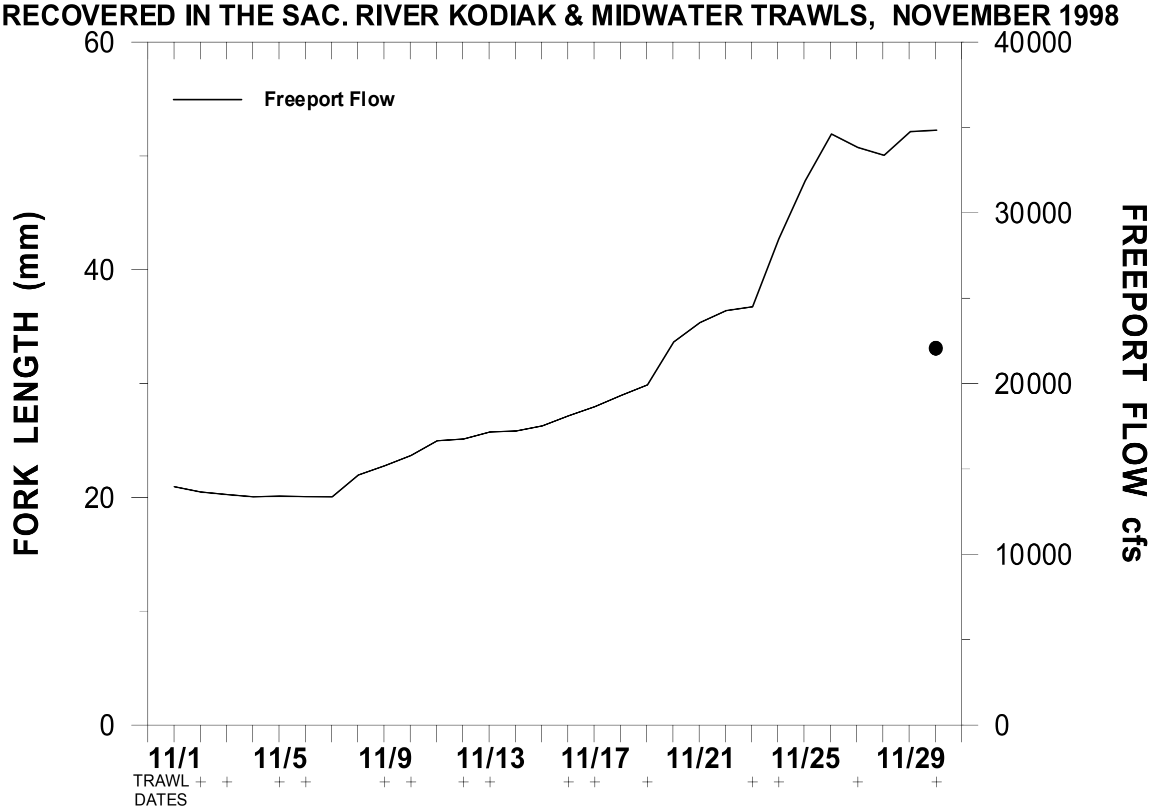


FIGURE 41. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, DECEMBER 1998

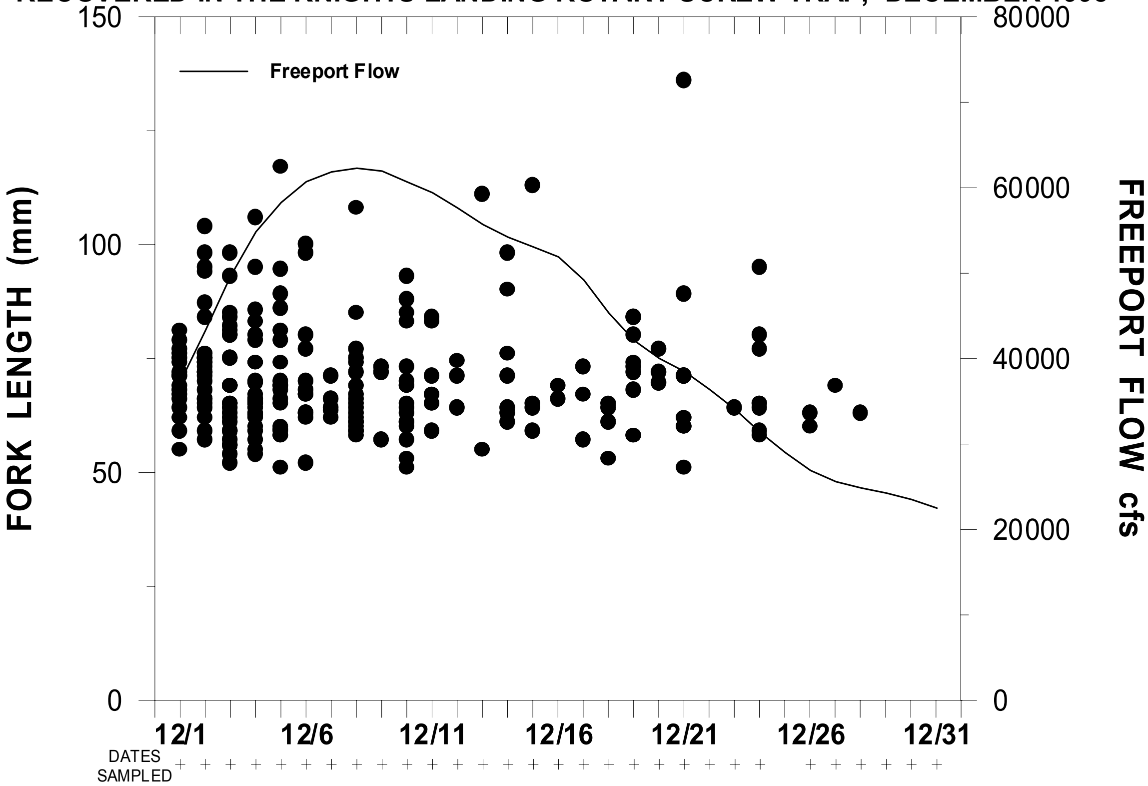


FIGURE 42. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWL, DECEMBER 1998

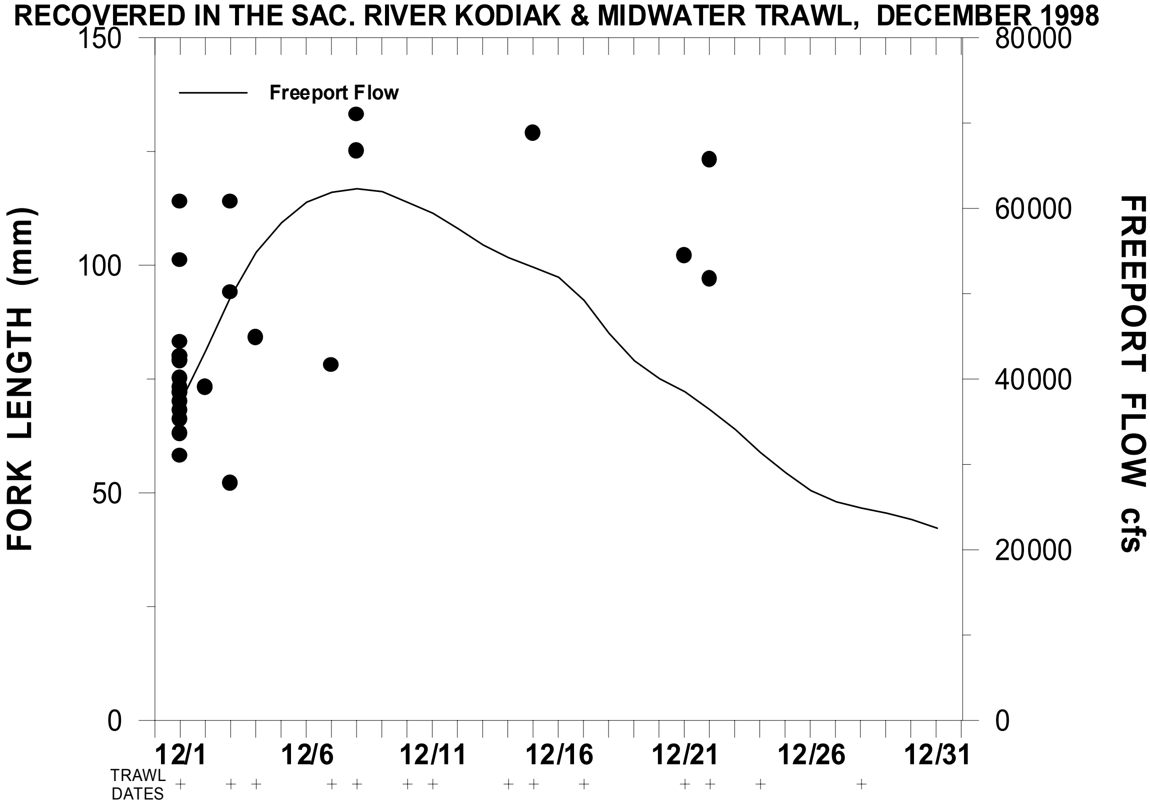


FIGURE 43. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, DECEMBER 1998

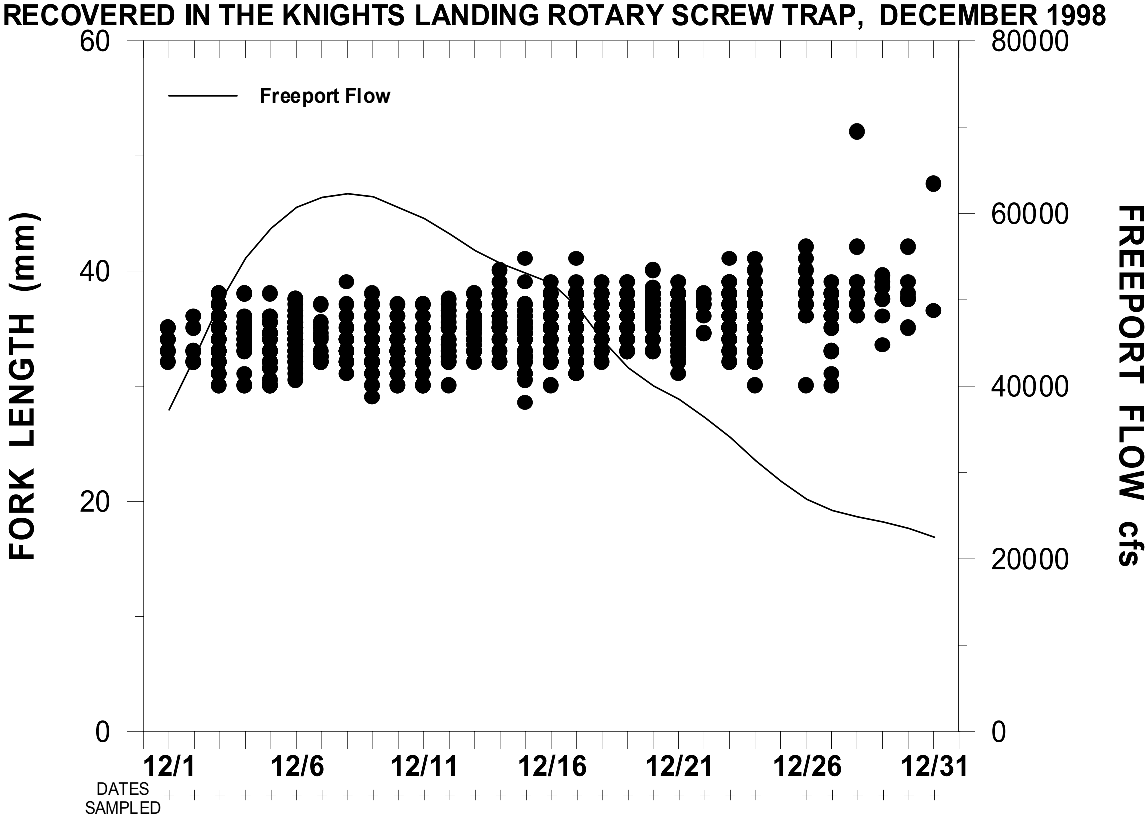


FIGURE 44. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWL, DECEMBER 1998

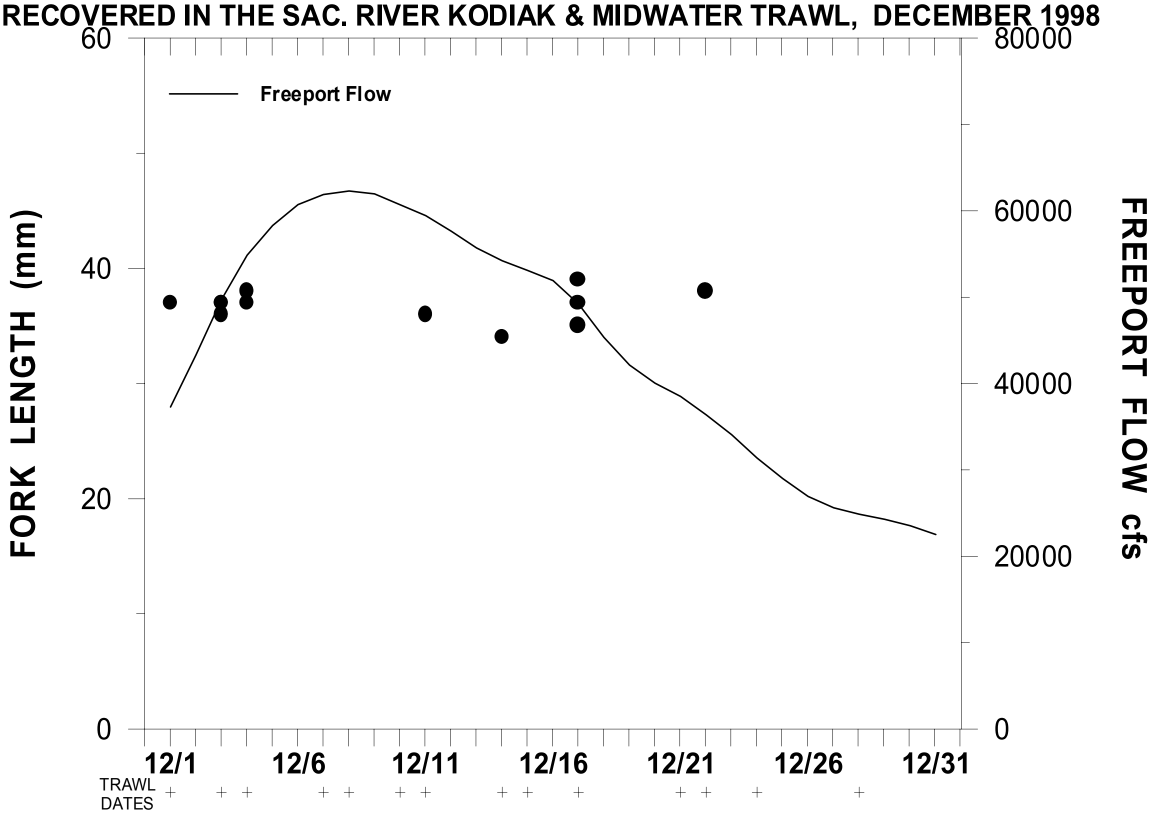


FIGURE 45. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, JANUARY 1999

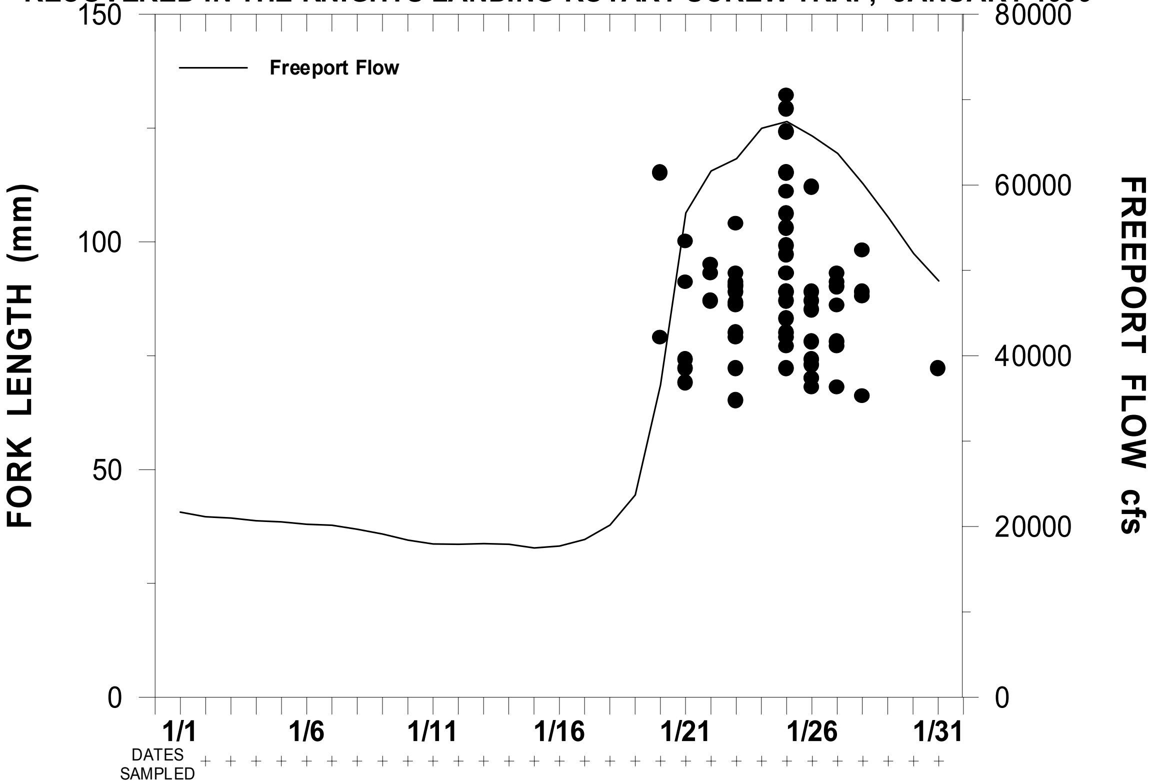


FIGURE 46. CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWL, JANUARY 1999

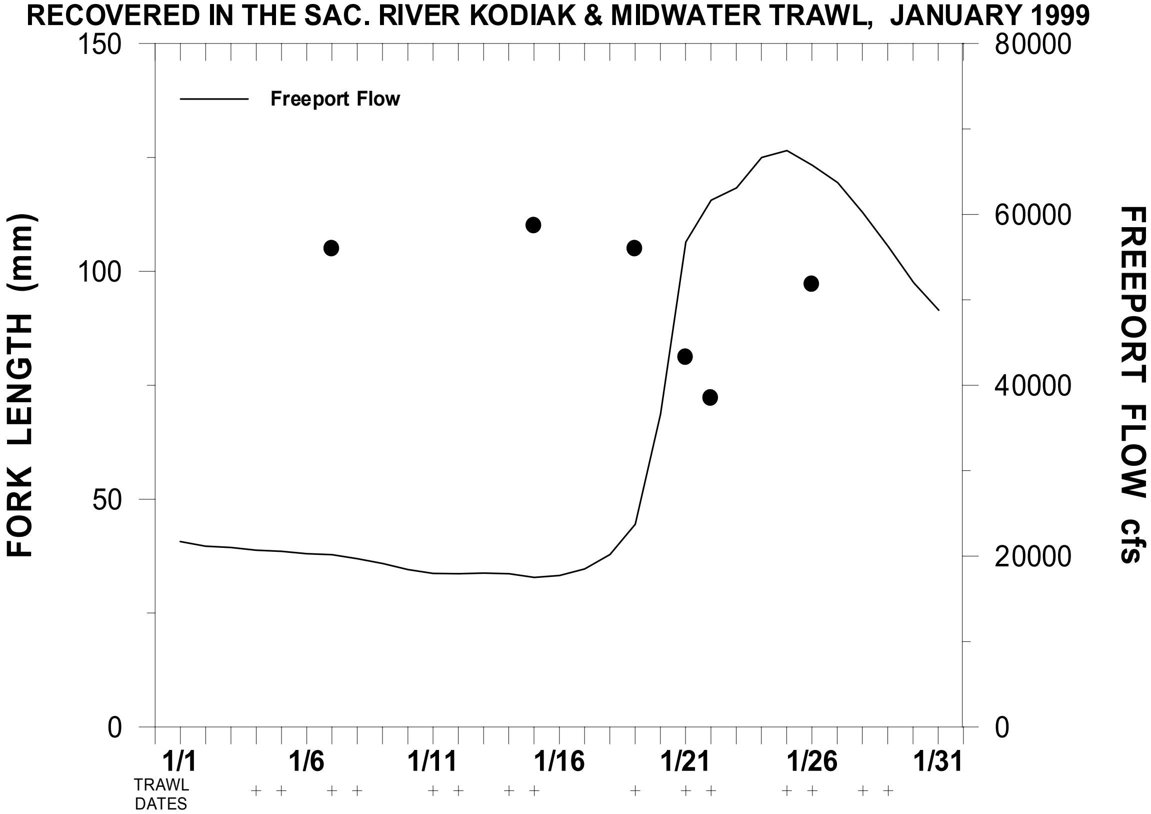


FIGURE 47. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, JANUARY 1999

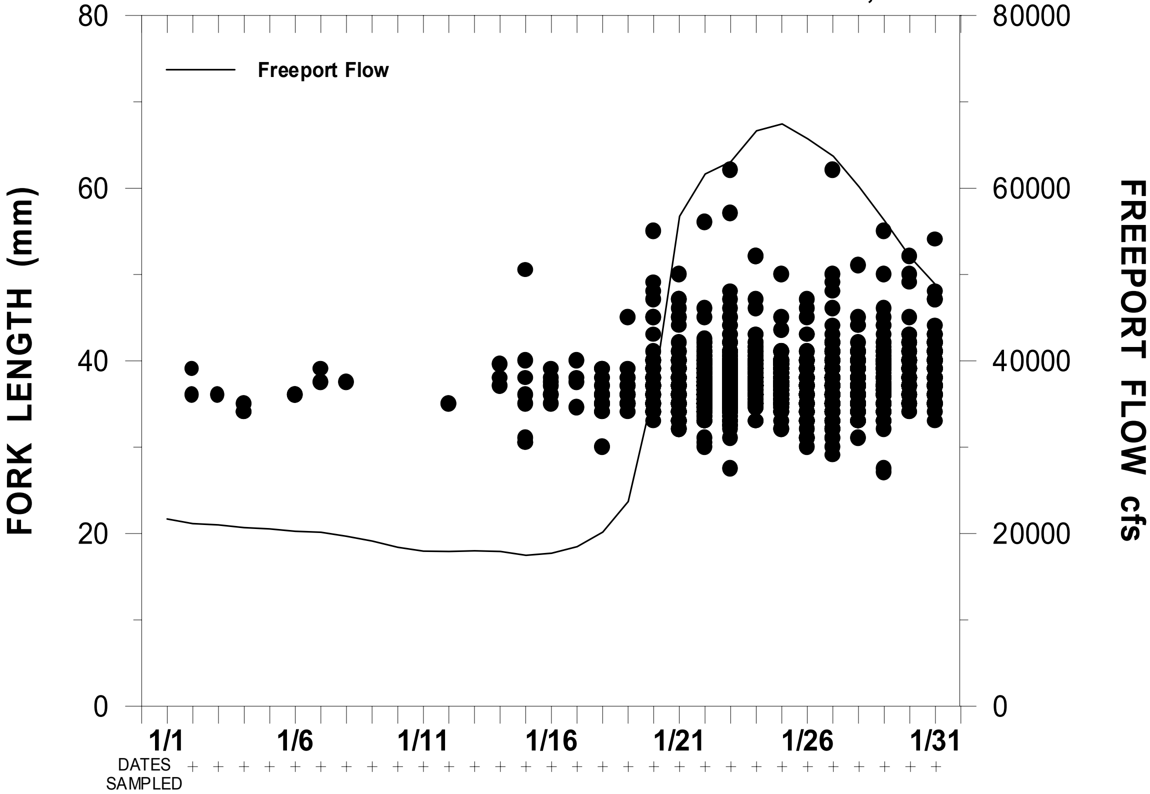


FIGURE 48. CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE RECOVERED IN THE SAC. RIVER KODIAK & MIDWATER TRAWL, JANUARY 1999

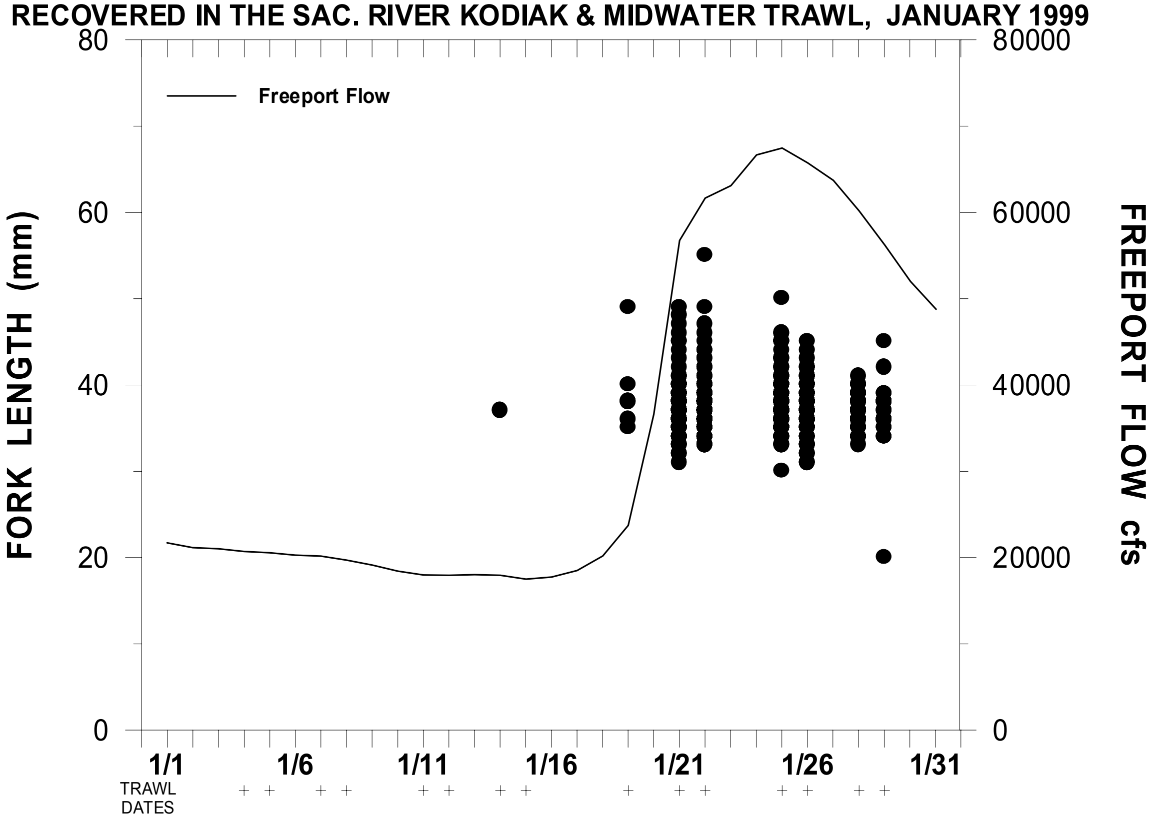


FIGURE 49. CATCH OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, OCTOBER 1995 - JANUARY 1996

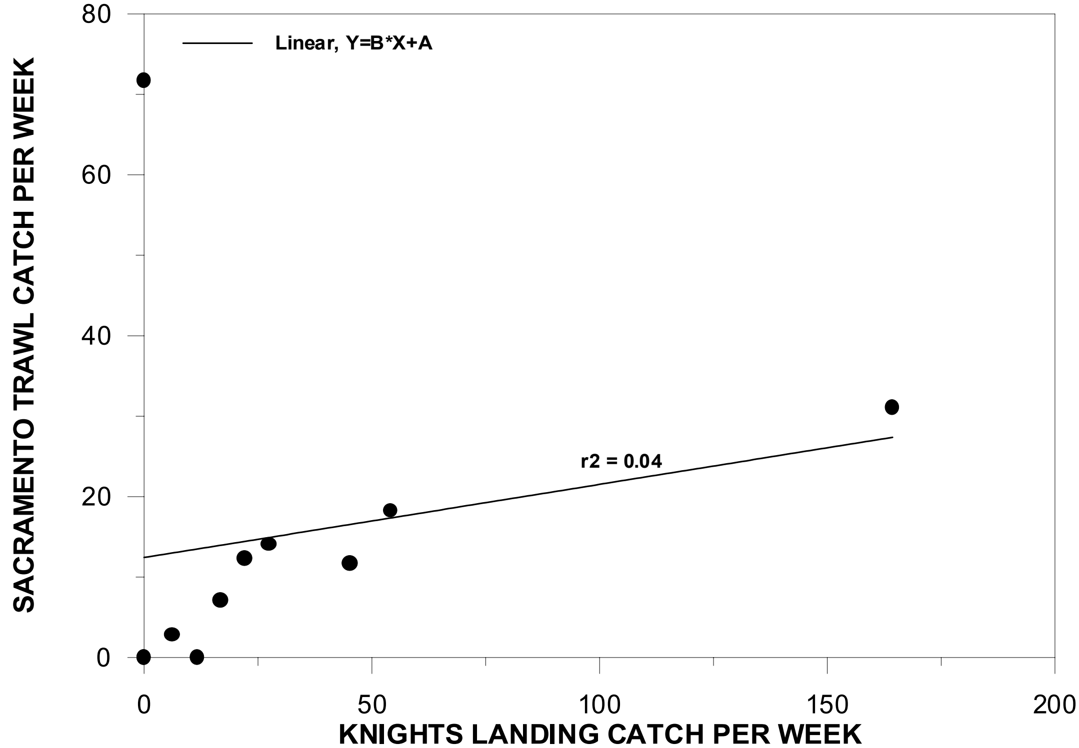


FIGURE 50. CATCH OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, OCTOBER 1995 - JANUARY 1996

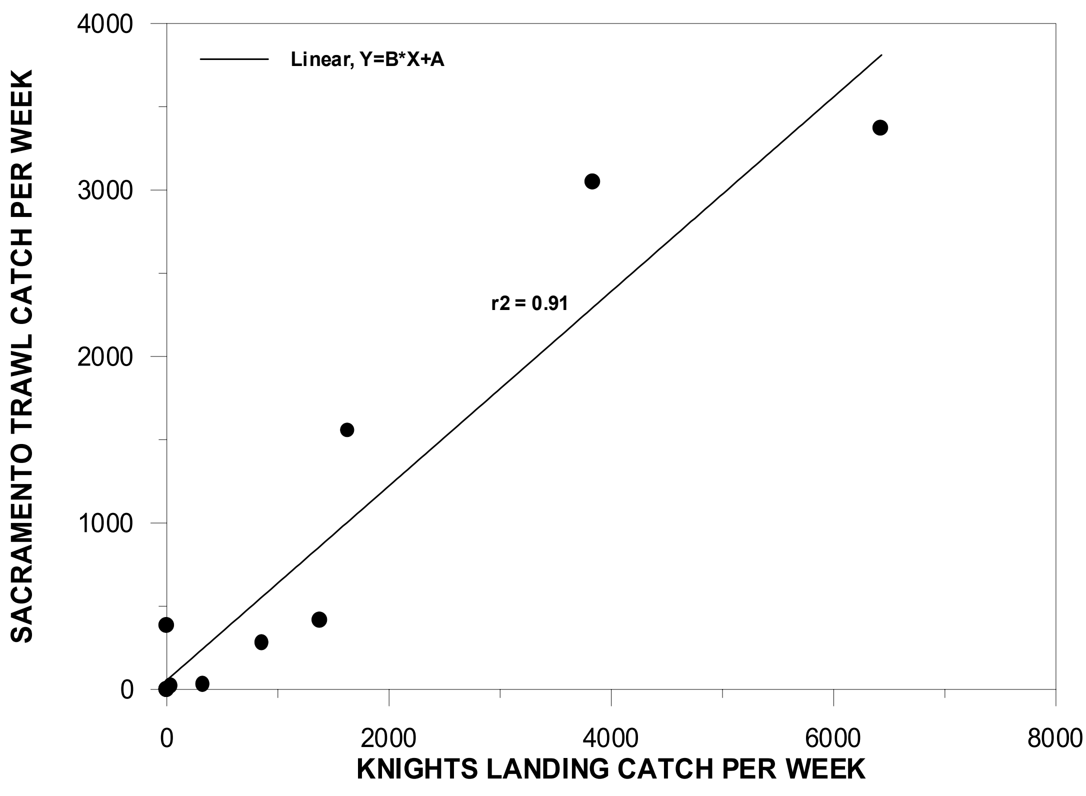


FIGURE 51. CATCH OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, OCTOBER 1996 - JANUARY 1997

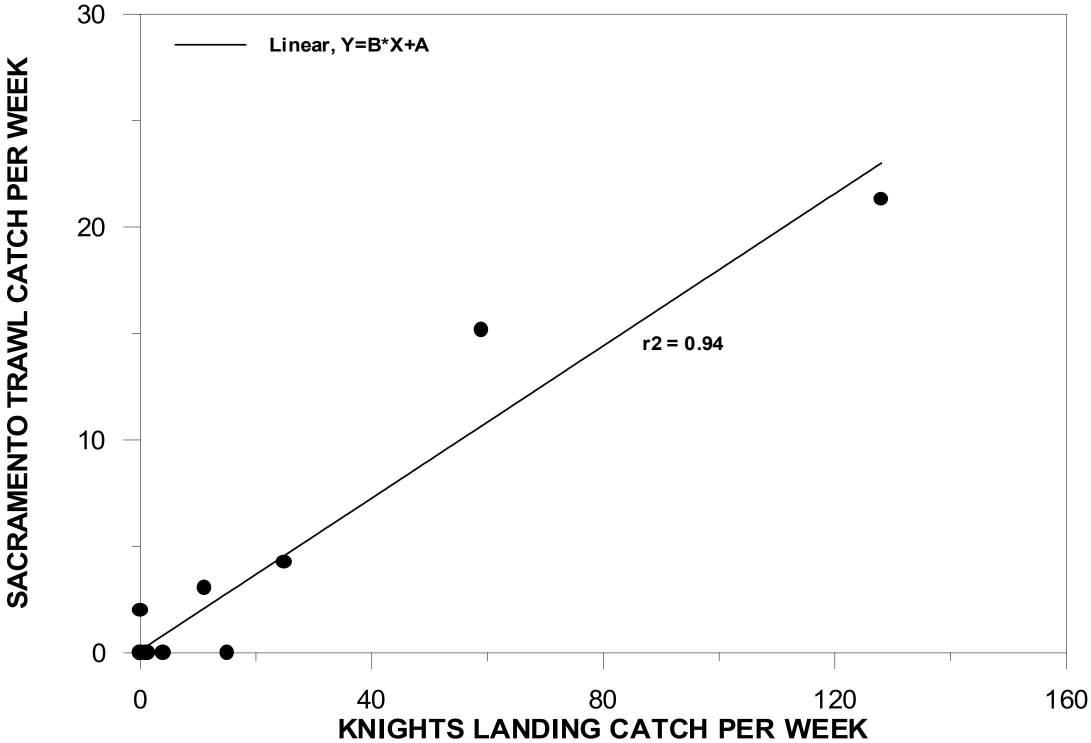


FIGURE 52. CATCH OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, OCTOBER 1996 - JANUARY 1997

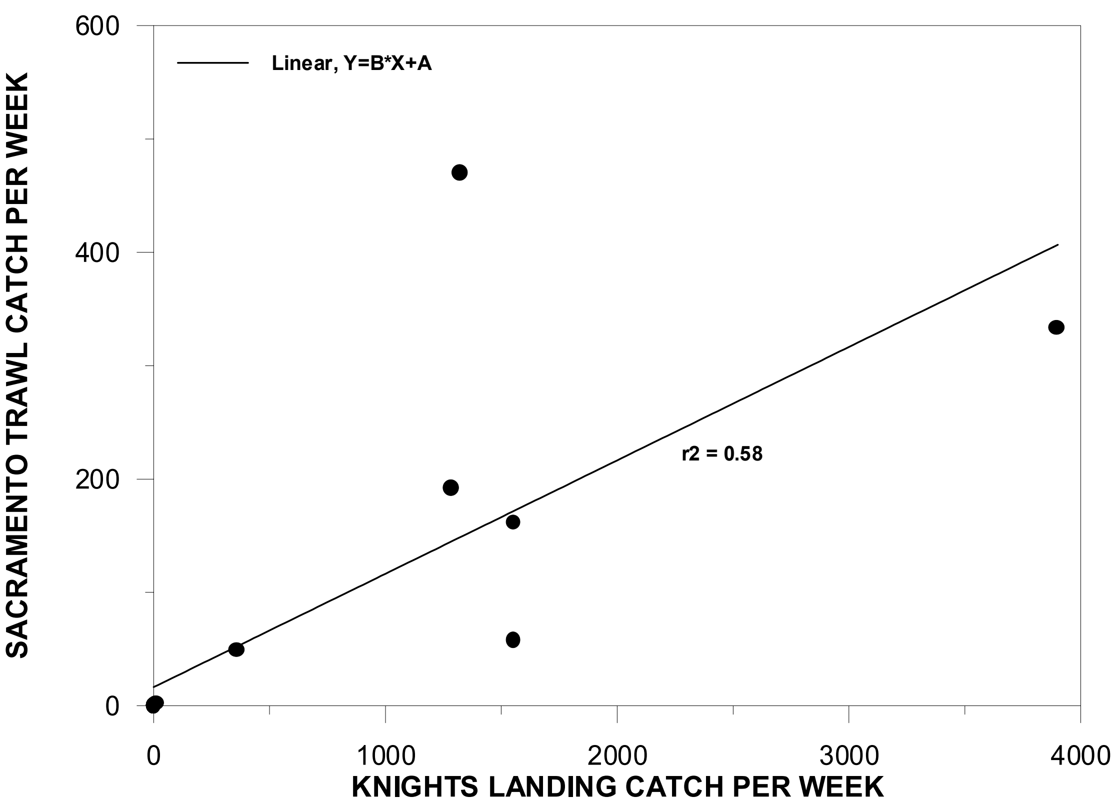


FIGURE 53. CATCH OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, OCTOBER 1997 - JANUARY 1998

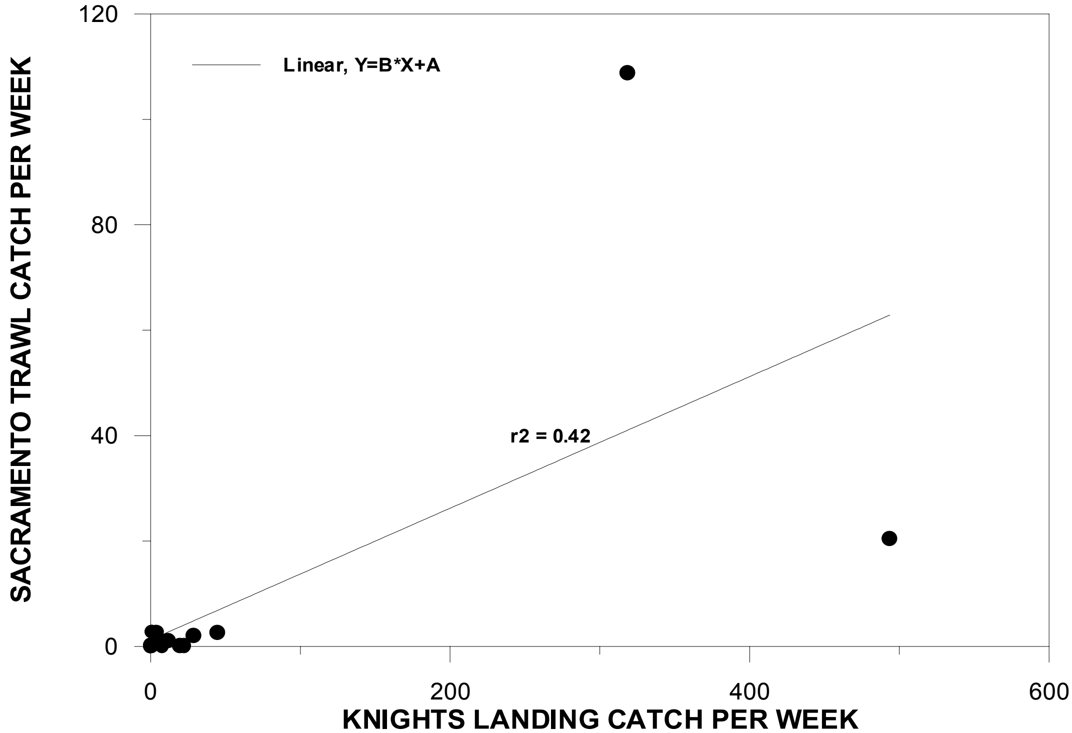


FIGURE 54. CATCH OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, OCTOBER 1997 - JANUARY 1998

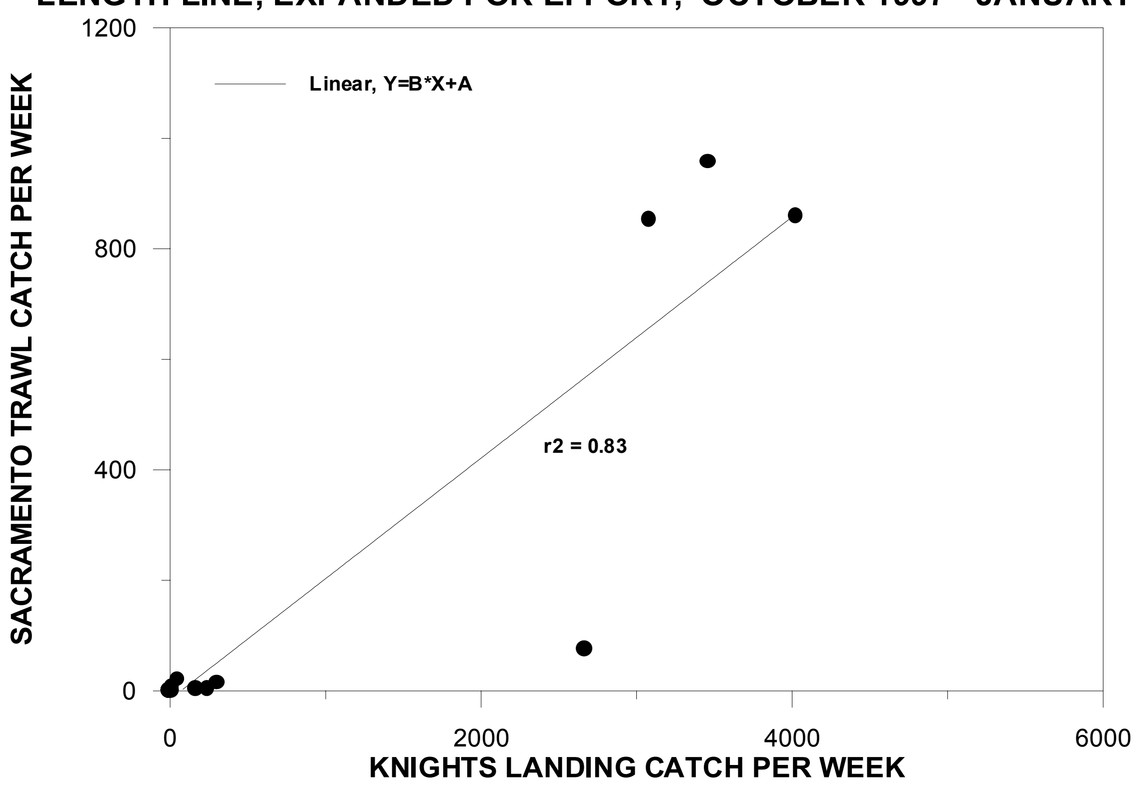


FIGURE 55. CATCH OF CHINOOK ABOVE THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, OCTOBER 1998 - JANUARY 1999

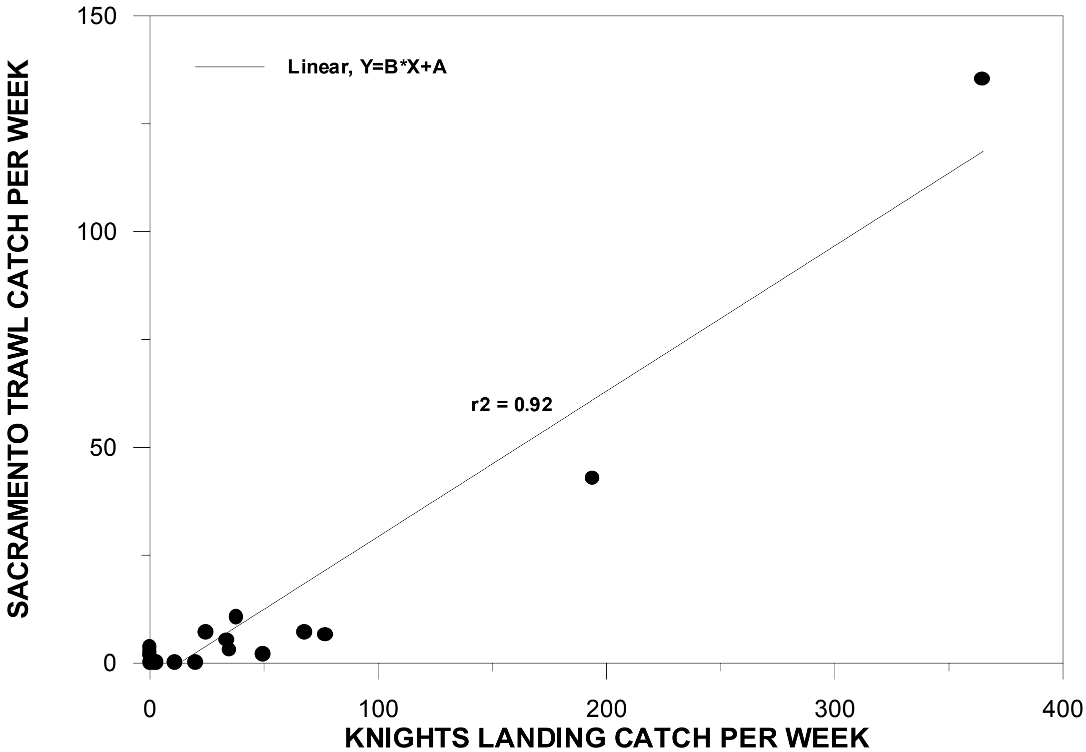
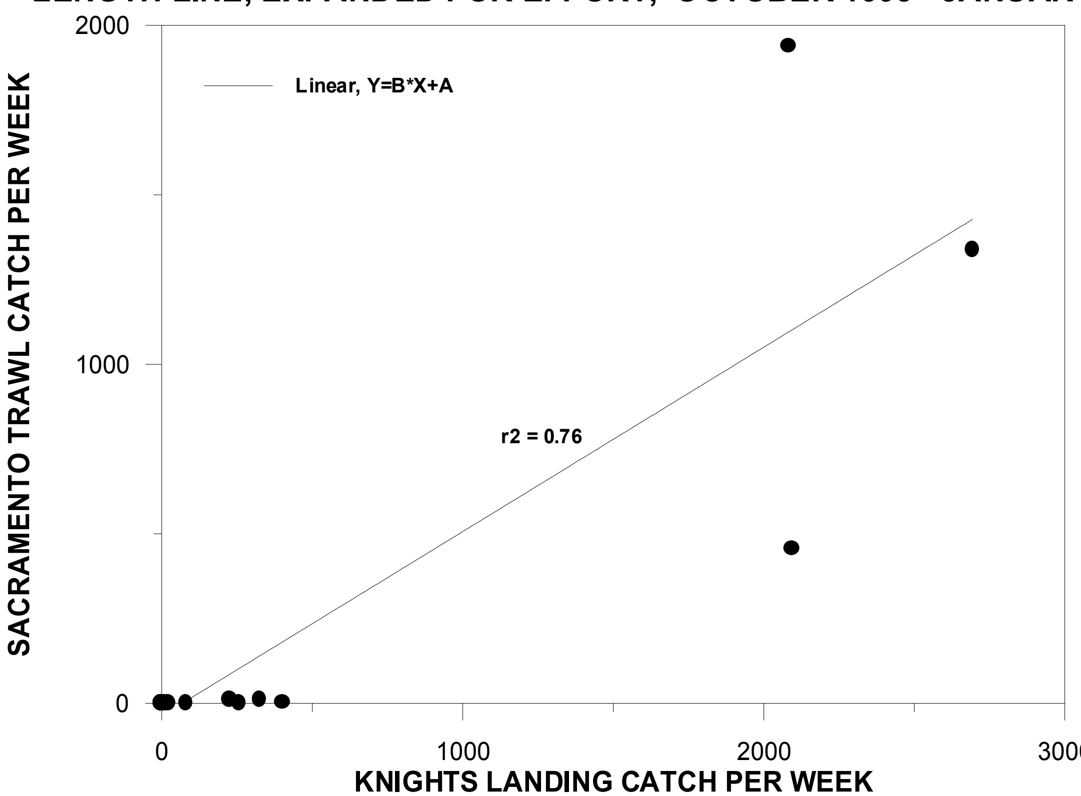


FIGURE 56. CATCH OF CHINOOK BELOW THE MINIMUM WINTER RUN LENGTH LINE, EXPANDED FOR EFFORT, OCTOBER 1998 - JANUARY 1999



APPENDIX 2

<u>Construction of **Table 25**</u>:
I examined the USFWS beach seine and Chipps Island mid-water trawl data to compile a list of fish species that have been reported during 1976 – 1999. Because the beach seine program was recently expanded to re-occupy some of the seine stations used by the DFG San Francisco Bay Study during 1980 – 1986, data collected by the Bay Study during that period are also included. A table of proportional abundances (by species) was compiled using a Braun-Blanquet-type ordinal scale.

A query posted to the Resident Fishes, Estuarine Ecology, and Shallow Water Habitat PWT reflectors was used to identify persons who have been using these data. Uses were roughly divided into "status and trends monitoring" and "research" categories. The "research" category, which accounted for most uses, included all applications not obviously intended to elucidate interannual variation in catch-per-effort or distribution. I did not make an effort to name persons using the data for salmon monitoring purposes.

The beach seine program will be part of the CMARP fishes monitoring plan (R. Brown, personal communication). Having some familiarity with these data, I used my own judgment to identify species for which the beach seine program is likely to be useful in status and trends monitoring. I also identified species for which the mid-water trawl program may similarly be useful, but these judgments are much less reliable.

The table of proportional abundances was expanded to include information about how the data are being used or might be used by adding four columns:

"Seine/S + T": Does it appear that beach seine data may be effectively used for status and trends monitoring of this species? (Note, for a few species the data are already being used for the purpose by investigators named in the rightmost column of the table.)

"Seine/Res.": Are the beach seine data being used (or have they been used) for research purposes? If yes, investigator(s) named to the right.

"CMWTR/S + T": Does it appear that Chipps Island mid-water trawl data may be effectively used for status and trends monitoring of this species?

"CMWTR/Res.": Are the Chipps Island mid-water trawl data being used (or have they been used) for research purposes? If yes, investigator(s) named to the right.